VOL. 8 SECOND QUARTER, 1937 No. 2

The Philippine Journal of Agriculture

PUBLISHED QUARTERLY BY
THE DEPARTMENT OF AGRICULTURE AND COMMERCE

MANILA
BUREAU OF PRINTING
1937

9186

THE PHILIPPINE JOURNAL OF AGRICULTURE

Published quarterly by the DEPARTMENT OF AGRICULTURE AND COMMERCE
Editorial Offices: DIVISION OF PUBLICATIONS, 732 Evangelista, Manila
[Entered at the Post Office at Manila, Philippines, as second-class matter]

The Philippine Journal of Agriculture

VOL. 8 SECOND QUARTER, 1937 No. 2

THE RATE OF PHOTOSYNTHESIS OF CARABAO MANGO LEAVES (*MANGIFERA INDICA* L.) UNDER FIELD CONDITIONS

By JULIAN A. AGATI

Of the Horticulture Section, Bureau of Plant Industry

TWO PLATES AND FOUR TEXT FIGURES

Since the leaves are necessary for the manufacture of food for nutrition, growth, and reproduction, one of the primary objects in cultural practices is to maintain in each tree as many healthy leaves as possible. However, while a large total leaf-surface may be needed for this purpose, ultimately it is the efficiency of the individual leaf, that is, the milligrams of carbon dioxide (CO_2) assimilated by a given area of leaves per unit time that really determines the usefulness of the individual leaf.

The present study was started in October, 1934. The first few weeks of the experiment were spent mostly in acquiring experience in the proper use of the apparatus. This work necessitated numerous trials both with and without the use of the leaves of the plants. After acquiring enough experience, the writer conducted preliminary tests on potted grafted mango seedling which lasted about seven months. Then, later in June, 1935, when materials became available the experiment was carried extensively on a matured carabao mango tree, *Mangifera indica* L., grown under field conditions located in one portion of the experimental ground near the Administrative Building of the Bureau of Plant Industry. This work was extended to March, 1936, a period of almost one year.

The rate of photosynthesis of the leaves was determined by finding the difference between the amount of carbon dioxide absorbed from a continuous current of normal air and that from a similar current of air previously passed through a chamber in which an active living leaf was enclosed.

The subject of photosynthesis has been generally well treated of in previous literature. Ample bibliographies were listed by Stiles(24), Spoehr(23) and many others.

APPARATUS USED IN THE STUDY

Apparatus closely similar to those devised and employed by Brown and Escombe(7) and by Heinicke and Hoffman(15) and aspirator tanks like those used by McLean(21), which serve to pull the air through the apparatus, were used in the present studies.

The principal parts of the apparatus (Plate 1) were the assimilation chambers, the five individual absorption units mounted on a common stand. The latter consisted of reservoir flasks and absorption towers, the flow meter, comprising the capillary tubes and improvised manometers, the aspirator tanks including their accessories, and the receptacle tanks which receive the water displaced in the respirator by the air.

The assimilation chambers.—These consisted of small rectangular envelope-chambers 8 by 15 cm. made up of cellophane paper, with openings at the bottom. (Plate 1, fig. A.) The chambers were prepared by folding loose sheaths of cellophane papers in packet-like form, closing all sides except the bottom. The opening at the bottom of the packet facilitated the insertion of the leaf and the tying together of the intake tube, the thermometer and the rubber tubings leading to the rest of the apparatus. The intake tube, 0.95 cm. in diameter glass tubing, 10 cm. long was bent slightly at almost obtuse angle at its free end. This served as a passage of air into the chamber. The thermometer, graduated from 0.0°C. to 100°C., recorded the temperature in the chamber. The chambers permitted the passage of normal amount of light (16) needed by the leaves.

Several U-tubes containing calcium chloride crystals (Plate 2, fig. A) were placed between the reservoir flasks and the assimilation chambers to collect the moisture that transpired from the leaves.

The reservoir flasks.—These consisted of 250-cc. capacity Erlenmeyer flasks of Pyrex glass. They were provided with

side necks for connections with the other parts of the apparatus (Plate 2, fig. B). Each flask was provided with rubber stopper with hole fitted with glass tubing about 20 cm. long that extended to the bottom of the flasks. The top end of the tube was connected to a rubber tubing to facilitate attachment to the rest of the apparatus. As will be shown later, these flasks contained the absorbent for the carbon dioxide that entered the apparatus.

The absorption towers.—The reservoirs were followed by five towers which were of Pyrex glass, about 2.5 cm. in diameter and 60 cm. long. Two of them were used as controls. They were held in vertical position by means of a wooden frame (Plate 2, fig. C) supported by a wooden bench, about 65 cm. high. With this arrangement, the apparatus was brought nearer the leaves used in the experiment. The basal ends of the towers were fitted with rubber stoppers having holes and glass tubings 0.95 cm. in diameter. These connected them with the reservoir flasks mentioned above. Just above the rubber stoppers at the base of the towers finely and uniformly folded beds of glass wools were placed so as to break the absorbent into small uniform bubbles. Thus certain scrubbing effect was produced, while the gas was brought in contact with the absorbent for a sufficiently long time. The top ends of the towers were connected to 100-cc. bottles (Plate 2, fig. D) each containing 60 cc. concentrated solution of sulphuric acid, for trapping the moisture, which otherwise clogged the capillary tubes (Plate 2, fig. E) and manometers (Plate 2, fig. F) which followed after the towers.

The capillary tubes were about 50 cm. long. They served to equalize the flow of air through the towers mentioned above. The manometers had a bore of about 0.35 cm. They were bent into U-shapes, one side being provided with short necks which connected them to the rest of the apparatus. The other end was left open. These manometers were protected by encasing them in flat small rectangular boards provided with scales (Plate 2, fig. G) for recording purposes. Approximately the same amount of liquid mercury was poured into each of the manometers. By means of this device, the pressure or velocity of the gas flowing into the respiratory tanks was regulated and recorded.

The respiratory tanks.—These followed the manometers. They were made up of iron drum (Plate 1, fig. C), and almost of the same size, each having about 50 gallons capacity. The

first one was used as a test tank and the other as a control tank. Both were placed side by side at vertical position on a tall table, about 105 cm. high (Plate 1). They were connected to the rest of the apparatus through holes bored on their top sides. This was accomplished by fitting small galvanized tubes into the tanks which in turn were fitted with rubber tubings to facilitate connections. The tanks were also provided with independent gauge and scales (Plate 1, fig. B) to record the volume of water displaced by the air entering the tanks. The tanks were also provided with outlets at the bottom by fitting snugly 1/2 inch faucets (Plate 1, fig. D) that could be opened simultaneously or regulated as desired. These faucets were connected to two arms of glass tubings (Plate 1, fig. F) and pulleys (Plate 1, fig. E) about one meter long each and 1.27 cm. diameter, and were protected by encasing them in bamboo poles of the same length and diameter. The arms were regulated by means of pulleys and tin can floats, having the same volume and size. With this device the volume of water displaced by the air entering the tanks could be regulated as desired. The water as being gradually displaced, flowed into the other tanks (Plate 1, fig. G) similar in form and size to the respiratory tanks.

MATERIALS USED

The grafted mango plant referred to above which was used first in this experiment was planted in a large galvanized pail. The plant was healthy, about two meters high, and three to four years old. The soil is sandy loam and was fertilized in 1934 with nitrophoska at the rate of 400 kilogram per hectare or 40 grams per tree. The soil was watered every other day to keep it reasonably moist during the experiment.

It may be mentioned in passing that the leaves used in this preliminary test started to assimilate as soon as the leaves turned pale green, reaching the maximum rate in about 12 to 13 days after their appearance, or in this case between the 23rd and 26th of November. The maximum assimilation registered was about 20.0 mg. an hour per 100 square centimeters of leaf-area. However, after this maximum was reached, the activities of the leaves assumed a gradual fall registering minimum rates as low as 5.0 mg. and 4.0 mg. per hour per 100 square centimeters in March and in May, respectively, when the leaves were from 180 to 210 days old.

Having already obtained such preliminary information in the course of assimilation of mango leaves, the experiment was

carried extensively and as thoroughly as possible on a matured tree about 12 years old, and approximately 7 to 8 meters high, and with a trunk diameter of almost 25 cm. The tree was healthy and prolific as shown by previous yearly harvests. The soil around the tree is a fairly rich sandy loam, and made constantly moist due to its proximity to a garden faucet. The elevation of the soil is but a few meters above sea level.

The studies consisted in determining the rate of assimilation of a given area per hour, during the entire growth of the leaves from the early stage up to or near their incision period.

In order to secure the best materials possible, four healthy buds of the same age from different branches of the tree were selected. After they opened, only two were actually used, the others were maintained as substitutes in case those first selected would fail to develop until maturity. Three vigorous looking leaves were finally selected from the first bud, designating them as LA–1, LA–2, and LA–3. The other three from the second bud, were marked LB–1, LB–2, and LB–3. These two sets of leaves were used alternately throughout the entire period of the experiment. As may be shown later in a more detailed manner, the rate of assimilation was given in milligrams of carbon dioxide per hour per 100 square centimeters of the leaf-area. The method employed in finding the area of the leaf was essentially the same as that of Heinicke and Hoffman(14). An accurate print of the leaf was first obtained by placing its lower side against a white cardboard and then daubing the edges of the upper side with a fine cheese cloth moistened with a dilute aqueous solution of light green. The area of the print which corresponded to that of the leaf was measured by means of a planimeter.

METHODS AND PROCEDURES

As may be seen from the following discussions, there are quite a number of salient points in the methods that need to be stressed. Obviously, the method required some degree of precision and care in order to arrive at the desired results.

Preparation of acid and alkali solutions.—The alkali used was KOH, having a concentration of almost 1/5 normal strength. This was preferred to $Ba(OH)_2$ solution because the latter was liable to precipitate in the towers and thus interferred with the return of the absorbent to the reservoirs below. The standard acid used was approximately 1/10 to 1/20 normal HCl.

The stock solutions of acid and alkali were kept separately in 20-liter demijohns in the laboratory. Burettes were employed

for transferring the alkali solution from the stock bottle to the flasks. This minimized the introduction of errors arising from the absorption of carbon dioxide from the air.

Filling the reservoir flasks.—The flasks were filled with 100 cc. KOH each. The volumes were made up to 200 cc. by adding 100 cc. of redistilled water obtained from the Bureau of Science. Utmost care was exercised to prevent the entrance of CO_2 from the air, which otherwise introduced errors to the results. Such errors, however, could not be entirely eliminated, so allowance for the exposure factor was provided by exposing a certain amount of KOH from the time of filling the flasks to the time when they were taken back to the laboratory for titration. It was found that the exposure factor ranged from 0.5 to 1.0 mg. CO_2 per flask every determination. These were taken into account in the calculations of the results. After filling the flasks, they were taken to the field well stoppered to be attached to the rest of the apparatus.

Attaching the assimilation chamber.—As soon as the intake tube, the thermometer, and the glass tubing were tied together near the petiole of the leaf, the cellophane-chamber was slipped over the leaf and tied snugly at the bottom so that there was no passage of air except through the intake tube. Care was taken not to injure the leaves so as not to impair their function. Three chambers were used. The two control units were not provided with chambers but with free intake tubes that extended near the chambers. These were used to measure the CO_2 content of the air.

The experiment was then ready to be started. It may be stated in this connection, that before the experiment was actually started, all the connections were made air-tight as the apparatus would not run properly even with the slightest leak.

Meteorological records.—The temperatures of the air both in the open and in the shade, and that of the assimilation chamber were recorded during the experiment. Likewise, the temperatures of the tanks as well as the relative humidity of the air were noted. The readings of the barometric pressure were obtained from the records of the Weather Bureau. The conditions of the sky as well as the degree of exposure of the leaves to sunlight were noted each hour during the experiment. On account of the absence of illuminometer, the conditions of the sky, that is, the amount of sunlight striking the surface of the leaves was given in relative terms.

Starting the experiment.—The faucets of the aspirator tanks were opened simultaneously. The flow of water was regulated so as to have almost the same discharge from the respiratory tanks. As soon as the solution in the flasks rose to the towers and bubbled, the initial volumes of the tanks were read. Most of the experiments lasted three hours. Only a few were conducted for two hours.

The final volumes of the respirator tanks were read at every close of the experiment. The assimilation towers were always detached before the faucets were closed. This prevented the KOH solution from being sucked into the tank. The towers were thoroughly washed with about 150 cc. of distilled water which was allowed to run into the flasks. This insured the complete recovery of all the CO_2 absorbed by the KOH solution(1). The flasks were then disconnected, stoppered tightly, and brought back to the laboratory for titration.

Titrating the KOH solution.—The contents of each of the five flasks were transferred into 500-cc. volumetric flasks, rinsing the former thoroughly with distilled water. The solutions were treated with 10 cc. of 25 per cent Barium chloride solution and shaking the mixture vigorously to complete the precipitation. Finally, each volume was made up to 500 cc. and transferred to well stoppered one-liter bottles. They were allowed to stand for some time to allow the precipitates to settle at the bottom of the bottles.

As soon as the precipitates have settled down in each bottle, 50-cc. portions of the clear liquid were drawn out with a pipette and titrated against a standard HCl acid solution using Phenolpthalein as an indicator. At least five replications from each bottle were made so as to bring the errors to the minimum. Phenolpthalein was used because it shows the completion of simple KOH-HCl reaction; it has a distinct end point, besides being sensitive to CO_2.

METHODS OF CALCULATING RESULTS

Suppose we take as an example, one unit, that is, one leaf, attached to a flask and a tower. In this specific case, 50 cc. of 0.2260 N KOH was neutralized by 17.2 cc. of 0.1150 normal HCl, or the total 500 cc. alkali required 172.0 cc. of the acid. In this case, the acid equivalent of 1 cc. of the alkali, which was obtained by dividing its normality by that of the acid, is 1.9652 cc.;

and its CO_2 equivalent as calculated from the usual chemical equation was 4.972 mg. $2KOH+CO_2 \rightarrow K_2CO_3+H_2O$
$K_2CO_3+BaCl_2 \rightarrow BaCO_3+2KCl$.

Now, in order to find the amount of alkali left after the original volume had reacted with the CO_2, that entered the apparatus, divide 172.0 cc. by 1.9652 cc., the acid equivalent of 1 cc. KOH, giving 87.52 cc. KOH. This amount is an excess of the original KOH solution or the amount that had not been reacted by CO_2.

Comparing the two control units, that is, those through which "fresh air" passed with the test referred above, the amount of KOH left after reacting with CO_2 was 91.59 cc. and 87.01 cc., respectively, or with an average of 89.30 cc. This amount of KOH represents the remainder or excess from the original solution in the two towers after it reacted with the entire amount of CO_2 that entered the apparatus, since there was no leaf to absorb a part or all of the carbon dioxide.

Now, therefore, in order to find the assimilation of the leaf attached to the tower referred above, substract 87.52 cc. from 89.30 cc., leaving 1.78 cc. Multiplying this remainder by 4.972 mg. CO_2, the acid equivalent of 1 cc. KOH, will give 8.85016 mg. CO_2, the assimilation of the leaf within a period of three hours. Finally, to find the apparent assimilation of the leaf per 100 sq. cm. per hour divide 100 by 39.10 sq. cm., the area of the leaf, and multiply the quotient by 1/3 and 8.85016 mg. CO_2 which gives 7.54 mg. CO_2. This represents the assimilation per 100 sq. cm. of leaf area per hour. From this will be substracted the exposure factor as suggested by Blackman and Matthei(1) which in this case is only 0.5 mg. CO_2. The final figure 7.04 mg. CO_2 corresponds to the net assimilation per hour per 100 sq. cm. leaf area.

EXPERIMENTS AND RESULTS

Dependability of the apparatus.—It was recognized at the outset of the experiments that the reliability of the results depended largely on the CO_2 absorption and also on such other factors as the rate of flow of air through the towers, the strength of the solution used and the length of time it was in contact with the air, duration of the experiment, size of bubbles, and the temperature of the liquid. Accordingly, these factors have been considered during the progress of the experiment.

The results of a few control experiments carried at various times under varying temperatures and atmospheric pressures are given in the tables below:

Table 1 consists of determinations made in the morning while Table 2 gives those carried in the afternoon. Both tables indicate the results of a few daily tests and few at weekly and monthly intervals.

Table 1 presents some 20 tests, 11 of which show 3 to 3.5 parts per 10,000 volumes of air, while the rest were below this proportion. The lowest proportion, 2.46 parts per 10,000 was recorded on December 10, 1935, while the highest, 3.48 parts per 10,000 was recorded in June of the same year. These variations were not surprising in view of the findings of Brown and Escombe (5), (6). These authors also found the same variations. It is interesting to note that except those recorded on September 13 and October 25 respectively all the high proportions occurred in the months of June and July. The low figures were observed during the months of August, November, and December. There was one exception, however, and that was in July when the proportion almost reached to 3 parts per 10,000. This is equivalent to the general accepted amount of carbon dioxide in 10,000 volumes of dry air.

TABLE 1.—*Carbon dioxide in the air expressed in volumes per 10,000 volumes of air. Computed from data obtained during three-hour periods between 8.30 and 11.30 a. m.*

Date	Volume of air in liters	Mg. CO_2 per liter of air	Computed CO_2 content of the air, expressed in volumes per 10,000 volumes of air
June 17, 1935	116.2	0.6482	3.30
June 18, 1935	138.9	0.6184	3.15
June 19, 1935	140.9	0.6372	3.26
June 20, 1935	131.5	0.6535	3.33
June 21, 1935	148.8	0.6844	3.48
July 1, 1935	149.7	0.5623	2.86
July 7, 1935	141.2	0.6589	3.35
July 15, 1935	147.5	0.5866	2.99
July 25, 1935	126.8	0.6636	3.38
August 12, 1935	133.6	0.5346	2.72
August 26, 1935	135.5	0.5623	2.87
September 13, 1935	121.8	0.6449	3.24
September 28, 1935	123.2	0.6239	3.18
October 14, 1935	133.2	0.5587	2.84
October 25, 1935	113.9	0.6611	3.37
November 6, 1935	121.7	0.6012	3.06
November 27, 1935	114.2	0.4975	2.53
December 10, 1935	117.7	0.4830	2.46
December 27, 1935	124.7	0.5815	2.96
January 6, 1936	118.2	0.5843	2.82

The figures in the afternoon tests, excepting that of January 16, 1936, were high in June, July, and September, respectively. The low figures occurred in November and December, 1935 and March, 1936. In this case, the highest figure was noted in July, 1935, while the lowest in December of the same year.

Apparently, the results of the morning and afternoon tests were more or less in accord with each other.

Perhaps, the augmented amount of CO_2 in the air during the early part of the experiment, that is, from June to July

TABLE 2.—*Carbon dioxide in the air expressed in volumes per 10,000 volumes of air. Computed from data obtained during three-hour periods between 1 and 4 p. m.*

Date	Volume of air in liters	Mg. CO_2 per liter of air	Computed CO_2 content of the air, expressed in volumes per 10,000 volumes of air
June 25, 1935	139.2	0.6525	3.31
June 26, 1935	139.9	0.6334	3.22
June 27, 1935	140.8	0.5979	3.04
June 28, 1935	145.3	0.6258	3.18
July 1, 1935	140.4	0.6311	3.21
July 7, 1935	141.2	0.6589	3.35
July 25, 1935	132.5	0.6465	3.29
July 31, 1935	140.9	0.6611	3.36
August 7, 1935	122.5	0.5555	2.83
August 21, 1935	132.0	0.5609	2.85
September 5, 1935	95.5	0.6424	3.27
September 23, 1935	131.4	0.6486	3.30
October 25, 1935	120.5	0.5933	3.02
October 30, 1935	111.3	0.6365	3.24
November 6, 1935	119.9	0.5217	2.65
November 13, 1935	108.2	0.6258	3.19
December 16, 1935	105.3	0.4909	2.50
January 16, 1936	133.0	0.6528	3.31
January 29, 1936	123.3	0.5849	2.97
February 13, 1936	129.4	0.6222	3.17
February 26, 1936	121.9	0.5986	3.05
March 4, 1936	136.6	0.5073	2.58

was due to the respiratory activities of the leaves. Under this period, the buds of the plant under experiment were in great activity. It seems likely that at this stage oxygen was taken in while an equal amount of CO_2 was given off.

Air supply and rate of assimilation.—Previous investigators (4), (20), (1), and (23) have found that if the amount of CO_2 is enriched, the assimilations of the leaves increased several times. On the other hand, assimilation is reduced in a limited volume of air due to the small amount of CO_2.

The writer's experiments were carried under conditions where the amount of CO_2 present depended on the quantity of air that entered the assimilation chambers. In other words, normal rates of assimilations were governed by the supply of air per one square centimeter leaf-surface enclosed.

Heinicke and Hoffman (14) concluded from their experiments that about 2 to 2½ liters of air per square centimeter of leaf-surface, enclosed in a chamber would be just enough to supply the amount of CO_2 that just equalled the amount of CO_2 available under natural conditions. They stated that the rate of assimilations under this condition was normal but below this amount the rate would be subnormal.

According to our results, the number of liters per square centimeter of leaf-area per hour of the A-series leaves in the morning, ranged from 0.37 to 2.93 or an average of 0.95 liter per square centimeter per hour. In the afternoon it ranged from 0.47 to 2.18 liters, or an average of 0.79 liter per square centimeter per hour. The daily average for these leaves was 0.87 liter per square centimeter of leaf-area per hour.

The number of liters per square centimeter of leaf-surface per hour of the B-series leaves in the morning ranged from 0.42 liter to 1.61 liters, or an average of 0.62 liter per square centimeter per hour. Those in the afternoon ranged from 0.42 to 1.12 liters, or an average of 0.63 liter per square centimeter per hour. The daily average for all the leaves was 0.80 liter per square centimeter of leaf-surface per hour.

The above figures, compared with those of Heinicke's and Hoffman's (14) are rather low. It is, however, interesting to note that Brown and Escombe (4) gave figures as low as 0.2 liter per square centimeter per hour, while McLean's were much less.

In considering the amount of CO_2 supplied, the effects of the movement of air over the leaf enclosed in the chamber should be determined also. Brown and Escombe (3) and others have worked on this, but mainly on higher rates. Heinicke and Hoffman (14) reported that the mean velocity of the air movement over the leaf in the cup chambers they used was about 7 meters per minute. In the writer's experiments the air movement recorded was only about 2 meters per minute. Perhaps the differences were due to the size of the assimilation chambers used and the manner by which the air was pulled through the apparatus. It is interesting to note, however, that the air entered the writer's apparatus about 10 times as fast as in McLean's

apparatus in which aspirator tanks were also used for pulling the air through the system.

As already mentioned elsewhere, the first set of three leaves was designated respectively as LA–1, LA–2, LA–3, and those of the second were labeled LB–1, LB–2, and LB–3. These leaves were borne by middle-age branches on the northern half of the crown of the tree.

Leaves LA–1 and LA–3 were both attached on lateral branches, while leaf LA–2 was borne by a terminal branch. They were all situated northwest in the crown of the tree.

Leaves LB–1 and LB–2 were also on lateral branches situated northwest, while LB–3 was borne by a terminal branch, situated directly north.

The daily exposure of the leaves as observed and recorded hourly throughout the experiment is summarized as follows: Leaf LA–1, excepting between 8 and 9 o'clock in the morning and between 12 and 1 in the afternoon, when they were partially shaded, the exposure up to 4 o'clock was very adequate. Leaf LA–2 was partially shaded at 8 o'clock a. m. and 12 noon, but well exposed the rest of the day up to 4 p. m. Leaf LA–3 was well exposed from morning up to 3 p. m. but partially shaded towards 4 p. m. Excepting between 12 to 1 p. m. when it was partially shaded, LB–1 was adequately exposed till the closing of the experiment at 4 p. m. Leaf LB–2 was partially shaded between 8 to 9 a. m. and 12 noon, but it was well exposed the rest of the day. Leaf LB–3 received sunlight throughout the day.

It is thus evident that the leaves were sufficiently well exposed to sunlight each day, except for a brief period in the morning and at noon, respectively, when few of them were partially shaded. Heinicke and Hoffman(14) stated that generally a leaf that is poorly exposed would still receive more than 1,000-foot candles of light. They stated further that the amount of light reaching the surface of an active leaf varies from 50-foot candles on a dull cloudy day, to 11,000-foot candles on a clear bright day. They estimated that about 12,000-foot candles are equivalent to one-eighth of full sunlight.

The prevailing weather conditions and the mean temperatures during the experiment were also given. Because of the absence of illuminometer for accurate measurement, the light conditions were given in relative terms which for the sake of clearness are illucidated herewith. The term "clear" was used to

mean that the sunshine persisted the whole day; "Partly cloudy," when passing clouds occupied about one-half of the sky and persisted only one-half of the day, either in the morning or in the afternoon; "cloudy," when two-thirds or more of the sky

TABLE 3.—*Fluctuation in photosynthetic activity of leaves A-1, A-2 and A-3 (Average of three-hour determinations between 8.30 a. m. and 11.30 a. m.).*

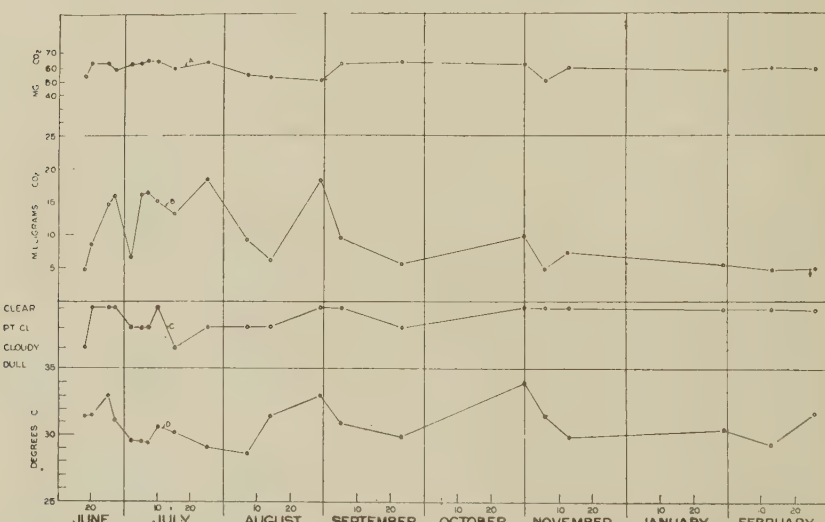
Date	Average CO_2 assimilations (Mg. Hr. 100 Cm_2)	Sky	Temperature		
			Minimum	Mean	Maximum
1935			°C.	°C.	°C.
June 15	-1.3	Cloudy	27.0	30.3	33.5
June 17	10.7	Clear	27.0	32.9	38.8
June 19	11.8	Clear	27.0	32.3	37.5
June 21	13.4	Clear	27.5	31.7	35.9
June 26	17.2	Cloudy	27.0	30.4	33.8
June 28	24.9	Clear	28.0	30.0	32.0
July 1	10.2	Clear	28.5	30.5	32.5
July 3	17.1	Clear	25.0	28.8	32.6
July 6	20.2	Partly cloudy	27.0	28.5	30.0
July 9	23.2	Clear	26.5	29.8	33.0
July 11	11.5	Clear	28.0	30.6	33.1
July 13	15.6	Dull	25.0	26.7	28.3
July 16	12.5	Clear	25.0	29.1	33.2
July 26	12.2	Cloudy	27.0	28.2	29.3
July 31	13.1	Clear	25.9	31.1	36.3
August 8	16.5	Clear	30.5	30.8	31.1
August 12	14.5	Clear	26.8	28.8	30.9
August 16	15.8	Clear	29.1	30.0	30.8
August 21	10.8	Clear	28.9	29.8	30.7
August 26	17.3	Clear	28.8	30.4	32.2
September 9	10.8	Clear	28.5	30.7	32.8
September 13	14.7	Clear	30.6	31.8	32.9
September 25	15.9	Clear	29.5	30.9	32.3
October 2	9.8	Cloudy	27.9	31.2	34.4
October 14	8.7	Clear	28.8	30.8	32.8
October 25	6.5	Clear	27.5	31.0	34.4
November 2	4.9	Clear	26.3	31.0	35.6
November 9	4.5	Cloudy	25.9	28.2	30.5
November 20	7.3	Clear	26.0	29.7	33.3
November 23	5.4	Clear	25.4	29.4	33.4
November 29	7.7	Clear	27.5	29.7	31.8
December 10	7.4	Partly cloudy	26.5	29.7	32.8
December 16	9.6	Clear	27.8	31.2	34.5
December 27	7.5	Clear	26.3	31.0	35.6

were dark for about one day; and "dull," when the sky was completely cloudy or dark the whole day and generally followed by short showers or rains. The days during the experiments were usually accompanied by a gentle breeze to slightly fast winds.

The results of the determinations on the first set of leaves in the morning are shown in Table 3, and those in the afternoon in Table 4.

Table 3 represents the average determinations of leaf LA–1, LA–2, and LA–3 in the morning, while Table 4 gives the average afternoon determinations of the same leaves.

As may be seen in the graph corresponding to Table 3, the photosynthetic activity of the leaves were rather irregular; on June 15, the leaves showed a negative assimilation. Later on, however, it ascended to a considerable height on June 28, about two weeks after the experiment was well under way. The rate then dropped on July 1, but rose again on July 6 and 9,



GRAPH 1.—Average CO_2 assimilation by leaves A-1, A-2, A-3 during three-hour determinations between 8:30 a. m. and 11:30 a. m. from June to December.

respectively. Finally, it declined on July 11 and remained at this point for sometime with but slight variations until finally on October 2, another conspicuous drop was sustained, the lowest minimum being recorded on November 9. From this time on, although slightly irregular, the course of activity was not so conspicuously variable as in the first months.

Apparently, the maximum activity of the leaves occurred between June 28 and October 2, when the leaves were from 12 to 100 days old. It was evident that the external conditions influenced the activities of the leaves as clearly shown during the latter part of June through July, and in November and December, respectively. The intervening time between these

two periods, however, that is, from July to November did not show close correlations between the rate of assimilations and weather conditions. Perhaps, in this case the internal factors, inherent in the plants themselves played a certain rôle.

Referring to Table 3 and its corresponding graph, it may be seen that the first assimilations were low, but later a steady rise was noted until the maximum rate was reached on the 28th day of June. As mentioned elsewhere in this paper, the maximum rate during the morning tests was reached about this

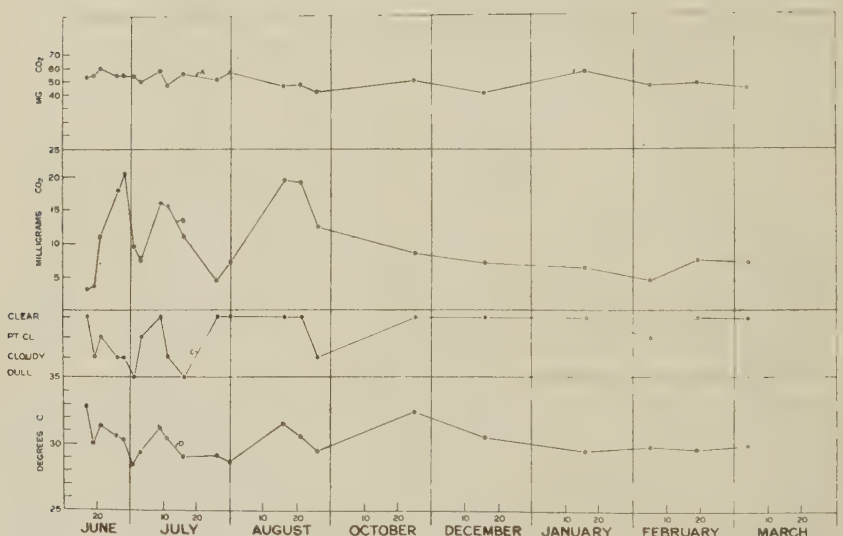
TABLE 4.—*Fluctuation in photosynthetic activity of leaves A–1, A–2 and A–3 (average of three-hour determinations between 1 p. m. and 4 p. m.)*

Date	Average CO_2 assimilations (Mg. Hr. 100 Cm2)	Sky	Temperature		
			Minimum	Mean	Maximum
1935			°C.	°C.	°C.
June 17	3.2	Clear	27.0	32.9	38.8
June 19	3.7	Cloudy	27.5	30.0	32.5
June 21	11.1	Partly cloudy	27.5	31.4	35.3
June 26	18.0	Cloudy	27.0	30.5	34.0
June 28	20.5	Cloudy	28.0	30.3	32.5
July 1	9.6	Dull	24.3	28.5	32.6
July 3	7.3	Partly cloudy	24.5	29.3	34.0
July 9	16.0	Clear	28.0	31.2	34.3
July 11	15.8	Cloudy	27.8	30.4	33.1
July 16	11.0	Dull	25.0	29.0	33.0
July 26	4.3	Clear	27.0	29.2	31.3
July 31	7.0	Clear	26.0	28.7	31.3
August 16	19.6	Clear	30.1	31.5	32.9
August 21	19.3	Clear	29.0	30.5	31.9
August 26	12.6	Cloudy	26.8	29.4	32.0
October 25	8.5	Clear	27.6	32.3	37.0
December 16	7.0	Clear	24.8	30.4	36.0
January 16	6.3	Clear	24.5	29.5	34.4
February 5	4.7	Partly cloudy	27.0	29.7	32.4
February 19	7.7	Clear	25.7	29.5	33.3
March 4	7.5	Clear	28.1	30.0	31.8

time also. On July 1, the activity went down, but increased again on the 9th, and about the end of the same month, it suddenly dropped. A few days later, it was noted that the leaves resumed their activity, attaining successive maximum levels on August 16 and 26. The leaves then became inactive until the close of the experiment, that is, after the leaves were about 260 days old.

Our observations showed that the influence of weather conditions to the activities of the leaves were more pronounced on June through October than later in the year.

Table 4 gives the afternoon determinations of the A-series of leaves. It may be noted that the performance, in the afternoon follow in general the trend of activities in the morning. As already intimated above, the highest rates of assimilations occurred mostly from the latter part of the first month to the latter part of the fourth month, after which time they showed a downward trend. Excepting that of July 26 and 31, the daily variations were likewise in general accord with the prevailing weather conditions. The results could be clearly seen in graph 2.



GRAPH 2.—Average CO_2 assimilation by leaves A-1, A-2, A-3 during three hour determinations between 1:00 p. m. and 4:00 p. m. from June to March.

Tables 5 and 6 give the morning and afternoon determinations of the leaves LB–1, LB–2, and LB–3. The data are plotted as shown in graphs 3 and 4.

The graph above shows that the maximum rate of the activity of the leaves occurred on June 27. It dropped on July 2, but later rose again, attaining high levels consecutively on the 14th and 29th of August, and on the 5th to the 11th of September. Apparently, resting the leaves at a few days intervals as in this case, stimulated their activity as shown by the September determinations. The leaves were not used until the early part of September. From this date, however, the activity dropped. Evidently, these leaves manifested a considerable activity between the latter part of June to the middle of September. In some instances, the external factors were in close accord with

the activities of the leaves, especially in June to early part of September.

Table 6 and the accompanying graph show the afternoon determinations of leaves, LB–1, LB–2, and LB–3. The maximum rates of activities of leaves were noted on June 25 and 27 and on July 5 to 25, respectively. Another maximum was recorded

TABLE 5.—*Fluctuation in photosynthetic activity of leaves B–1, B–2, and B–3 (average of three-hour determinations between 8.30 a. m. and 11.30 a. m.).*

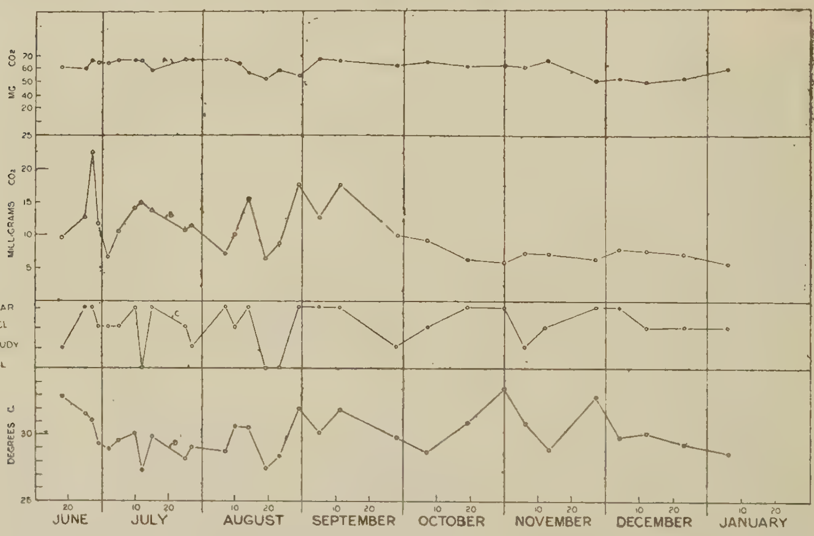
Date	Average CO_2 assimilations (Mg. Hr. 100 Cm_2)	Sky	Temperature		
			Minimum	Mean	Maximum
			°C.	°C.	°C.
June 18, 1935	9.4	Cloudy	27.0	32.3	37.5
June 25, 1935	12.7	Clear	28.7	31.5	34.3
June 27, 1935	22.5	Clear	27.8	31.6	35.4
June 29, 1935	11.5	Partly cloudy	28.3	29.4	30.4
July 2, 1935	7.2	Partly cloudy	24.3	28.8	33.3
July 5, 1935	10.5	Partly cloudy	27.7	29.5	31.2
July 10, 1935	14.1	Clear	27.8	30.1	32.3
July 12, 1935	14.9	Dull	25.8	27.3	28.8
July 15, 1935	13.7	Clear	27.5	29.8	32.1
July 25, 1935	10.7	Partly cloudy	27.3	28.1	28.8
July 27, 1935	11.1	Cloudy	26.5	29.0	31.5
August 7, 1935	7.0	Clear	25.7	28.7	31.6
August 10, 1935	10.0	Partly cloudy	30.2	30.6	31.0
August 14, 1935	15.4	Clear	29.6	30.5	31.4
August 19, 1935	6.2	Dull	26.3	27.4	28.5
August 23, 1935	8.7	Dull	26.9	28.3	29.7
August 29, 1935	17.6	Clear	31.3	31.9	32.6
September 5, 1935	12.7	Clear	28.0	30.1	32.2
September 11, 1935	17.8	Clear	29.8	31.8	33.9
September 28, 1935	10.0	Cloudy	26.8	29.7	32.6
October 7, 1935	9.2	Partly cloudy	25.5	28.6	31.6
October 19, 1935	6.2	Clear	28.8	30.8	32.8
October 30, 1935	5.9	Clear	27.9	33.4	38.8
November 6, 1935	7.2	Cloudy	26.0	30.8	35.6
November 13, 1935	7.1	Partly cloudy	26.4	28.9	31.3
November 27, 1935	6.3	Clear	29.0	32.8	36.5
December 4, 1935	7.9	Clear	26.3	29.7	35.0
December 12, 1935	7.7	Partly cloudy	26.8	30.1	33.5
December 23, 1935	7.0	Partly cloudy	23.5	29.3	35.1
January 6, 1936	5.6	Partly cloudy	24.9	28.6	32.3

on August 29. The first minimum rates were obtained consecutively on July 2, August 7 and 14, and lastly on September 5, while the later minima were noted on November 6 and on February 13. Although there were few exceptions, the activities of the leaves were to some extent influenced by external conditions.

In general, the activities of the leaves were correlated with the external conditions obtaining during the time of determina-

tions. For instance, most of the maximum rates of assimilations occurred during clear days with a goodly amount of sunshine. On the other hand, the minimum rates were generally associated with cloudy or dull days. Some exceptions were noted. For instance, on June 26 and 28 of the afternoon determination, and on July 6, of the morning determination of leaves A–1, A–2, and A–3 although it was cloudy, and the mean temperature low, the assimilations were comparatively high.

On the other hand, on November 2 and 23 although both days were clear with a goodly amount of sunshine, the corresponding assimilations were low. Perhaps in this case, the inactivity was partly due to the advanced stage of the leaves. The low rates



GRAPH 3.—Average CO_2 assimilation by leaves B-1, B-2, B-3 during three hours determinations between 8:30 a. m. and 11:30 p. m. from June to January.

on July 31 and on August 21, however, can not be attributed to old age. Perhaps the variations were due to the influence of the prevailing external factors.

Notwithstanding these few isolated contradictory figures, the results of the experiment in general indicated better rates of assimilations during bright sunshiny days and lower rates during inclement weather. This trend of activity persisted throughout the expirements.

The sharp daily variations in the activities of the leaves occurred from the latter part of June through August and September. The variations assumed a downward trend till the termination of the experiment. In some cases, however, the

last determinations showed upward tendencies which could not be explained. These findings corroborated those of Heinicke and Hoffmann(14) in the case of their studies with the apple

TABLE 6.—*Fluctuation in photosynthetic activity of leaves B-1, B-2, and B-3 (average of three-hour determinations between 1 p. m. and 4 p. m.).*

Date	Average CO_2 assimilations (Mg. Hr. 100 Cm_2)	Sky	Temperature		
			Minimum	Mean	Maximum
			°C.	°C.	°C.
June 18, 1935	4.7	Cloudy	26.0	31.3	36.6
June 20, 1935	8.4	Clear	27.5	31.4	35.2
June 25, 1935	14.8	Clear	28.8	32.9	35.0
June 27, 1935	16.0	Clear	28.0	31.0	34.0
July 2, 1935	6.7	Partly cloudy	24.5	29.5	34.5
July 5, 1935	16.0	Partly cloudy	27.5	29.5	31.4
July 7, 1935	16.4	Partly cloudy	27.0	29.3	31.5
July 10, 1935	15.1	Clear	27.8	30.5	33.2
July 15, 1935	13.1	Cloudy	26.3	30.1	33.9
July 25, 1935	18.3	Partly cloudy	27.5	29.0	30.5
August 7, 1935	9.1	Partly cloudy	25.6	28.5	31.3
August 14, 1935	6.1	Partly cloudy	29.8	31.3	32.8
August 29, 1935	18.2	Clear	32.1	32.9	33.7
September 5, 1935	9.5	Clear	28.0	30.9	33.7
September 23, 1935	5.8	Partly cloudy	28.8	29.8	30.7
October 30, 1935	9.9	Clear	28.9	34.3	39.7
November 6, 1935	5.0	Clear	25.9	31.4	36.8
November 13, 1935	7.7	Clear	26.3	29.8	33.2
January 29, 1936	5.5	Clear	27.9	30.7	33.5
February 13, 1936	5.0	Clear	27.0	29.5	31.9
February 26, 1936	5.1	Clear	31.0	31.8	32.5

leaves. Majority of the determinations, however, were in accord with the prevailing weather conditions.

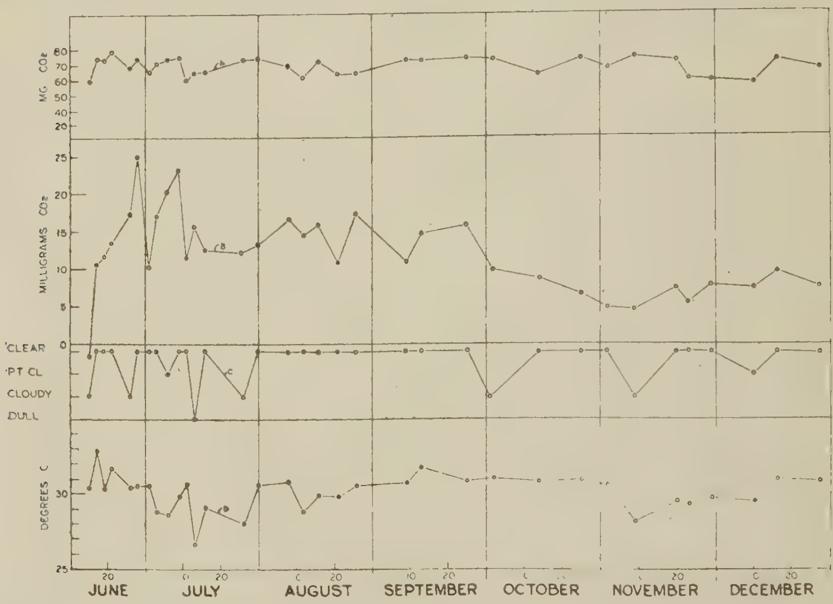
Apparently, the leaves assimilated most during their light green stage, especially in the morning. The same findings were noted by McLean(21) in his studies with coconut, abacá, and sugar cane.

As the leaves advanced in stage about 7½ to 8½ months old, and approached their incision period, they became inactive until finally they were replaced by the new leaves resulting from the buds of the following season.

DISCUSSION

The rates of photosynthesis of mango leaves were found to vary each day throughout the experiment. No two or more successive determinations for any length of time were the same. A maximum value may be followed by a low rate, or vice versa, depending on the conditions obtaining during the determinations.

Such variations in the writer's results were expected since in literature(23), (24), (21) and other sources; it has been shown that the photosynthetic activities of different crops showed wide variations in rates.



GRAPH 4. Average CO_2 assimilation by leaves B1, B-2, B-3, during three hour determinations between 1:00 p. m. and 4:00 p. m. from June to February.

Some of the low photosynthetic values in the writer's experiment were obtained from immature leaves on warm days, when the temperature registered as high as 36° C., or an increase of about 5° C. over the ordinary temperature. Under these conditions, young mango leaves when enclosed in a cellophane chamber showed incipient wilting. This perhaps impaired the functions of the leaves, with the consequent low photosynthetic activities. During the older stages of the leaves, the effect of high temperatures was not so evident, however. In fact high assimilation rates were associated with moderately high temperatures. In this case the increased humidity in the assimilation chamber favored the opening of the stomatas, so that in case the air supply was ample, the relative humidity and temperature were kept at nearly normal amounts, thus favoring appreciable rates of assimilation.

Perhaps one factor that influenced the rate of photosynthesis was the accumulation of by-products(16), (13). This perhaps accounted for the cause of the low values following high rates

in the writer's experiment. Obviously, also, inefficient absorption of CO_2 reduced the rate of photosynthesis. In this case, CO_2 was the limiting factor(2). See also Brown and Heise(8) and Brown(9). Very likely such limiting factor was at play in the writer's experiment when the leaves approached the wilting point when closure of stomatas was inevitable. Darwin(10) pointed out the relation of closure of stomatas to wilting of leaves. The decrease in the activities of the leaves may be due partly to "time factor" or to fatigue through continuous use Blackman and Matthei(1). In the present studies, the activities of the leaves were generally stimulated after having been rested a few days, that is, the leaves have not been in use due to inclement weather. Low rates were also associated with the color of the leaves. During their purple stage, the leaves showed low or negative assimilation. Perhaps this was partly due to the lack of chlorophyll and also to some other factors. Irving(18) stated that the amount of chlorophyll is not a factor limiting photosynthesis during the early stage of the assimilating organs but some component parts in the photosynthetic machinery that controls it. Evident activities were noted as soon as the leaves have turned light green, but no increase was recorded thereafter, that is, even after the leaves have become dark green. Such trend of photosynthetic activity was also observed by Ilgin(17) and Stiles(24).

The fact that the leaves were enclosed in envelope-chamber, it might be assumed that unless enough air was admitted to supply a nearly normal amount of CO_2, the photosynthetic activities have been at levels lower than in the open. Heinicke and Hoffman(14) reported that supplying the air at the rate of 2 to $2\frac{1}{2}$ liters per hour induced normal assimilation. The writer had no way of setting a pre-determined rate of air supply due to lack of appropriate apparatus. The figures obtained under the conditions of the writer's experiment were about one-half lower than those of Heinicke's and Hoffman's.

The higher values of photosynthetic activities in the writer's experiment were registered during days of sunshine alternated by rainy days. This occurred in the months of July and August to early part of September, when the leaves were about $2\frac{1}{2}$ to 3 months old. Perhaps the stimulation in the activities of the leaves was due to the augmented soil moisture which supplied the needs of the plant. Besides being an important factor for photosynthesis, water also induced the opening of stomates(23); Magnes and Furr(19), Dastur(11), Dastur and Desai(12) ob-

served the relation of the degree of turgidity of leaves to the rate of photosynthesis, that is, low water content induces closure of stomatas and consequently retards photosynthesis.

It was also observed that the active period of the mango leaves was characterized by rapid transpiration. The existence of relationship between the rate of transpiration and photosynthesis in the mango seems likely in view of the findings of Ilgin(17), who stated that the transfer of mesophytes to a dry habitat not only induces increased rates of transpiration but also stimulates photosynthesis. It was also observed that the mango assimilated and transpired less during their mature stage. Whether these observations are truly characteristic with the mango or not, it still remains to be proven in the light of further experiments.

While it may be possible to associate the rates of photosynthesis with the prevailing external conditions under which the experiment was conducted, it was difficult to determine exactly the other factor or factors which keep the activities of the leaves at a low level. Neither was it possible to list these factors in the order in which they act upon the plant. Perhaps a thorough experimentation along this line may shed light on this particular point.

SUMMARY

1. The present paper as reported here constitutes a year's study of the course of assimilation of mango leaves from young stage to maturity. The method employed seems to be satisfactory for comparative studies of the rates of photosynthetic activities during the different stages of the leaves arbitrarily indicated as pre-light green stage, light green stage, and dark green stage, and of the months of the year corresponding to these stages.

2. The leaves showed no photosynthetic activity right after they were formed, or still purple in color. Under these conditions, the first set of leaves showed negative assimilation. But 3 to 5 days after, as the leaves assumed a purplish green color, assimilatory activities were noted. Great activities, however, were not noted until after the leaves were about 15 days old. From this time on, lasting over three months (light green stage), the leaves manifested considerable activities. Then about four months later (dark green stage), until the close of the experiment, irrespective of the presence of favorable conditions, the rates of activities were comparatively low and never reached a maximum comparable to those obtained during the light green

stages of the leaves. It seems that the leaves past the light green stage are no longer active, but for the most part remain as "boarders" until they fall off due to natural incision.

3. Generally, the average assimilations in the morning are greater than those in the afternoon. At least most of the maximum rates were recorded during the morning determinations. It is also apparent that in most cases the fluctuations in assimilation agree with the predominating external factors.

4. This study should lend an aid to the understanding of the value and limitations of the standard cultural practices. Perhaps with the knowledge of the course of photosynthesis with respect to the ages of the leaves or to the time of the year, such cultural practices as pruning, smudging, spraying, or application of fertilizers could be administered to a great advantage. For example, pruning or application of fertilizers may be tried during the different stages of the activities of the leaves. Perhaps experiments along this line with the object in view of improving the yield may prove beneficial to fruit tree culture.

ACKNOWLEDGMENTS

The writer wishes to express his gratitude to Dr. Vicente C. Aldaba, Chief, Fiber Research Section, for his advice and suggestions during the early part of the work, and later for his help in appraising the results; to Mr. F. G. Galang, Chief, Horticulture Section, for his encouragement during the progress of the work; and lastly to a number of our assistants, particularly Messrs. B. P. Javier and A. C. Pasco for their help in performing the laboratory as well as the field work required by the experiment.

LITERATURES CITED

(1) Blackman, F. Frost, and L. C. Matthel. Experimental researches in vegetable assimilation and respiration. IV–A quantitative study of carbon dioxide assimilation and leaf-temperature in natural illumination. Roy. Soc. (London) Proc. B **76**: 402–460. 1905.

(2) Blackman, F. F. Optima and limiting factors. Ann. of Bot. **19**: 281–295. 1905.

(3) Brown, Horace T. and F. Escombe. Static diffusion of gases and liquids in relation to the assimilation of carbon and translocation in plants. Roy. Soc. (London) Phil. trans. B 193: 223–291. 1900.

(4) Brown, Horace T. and F. Escombe. The influence of varying amount of carbon dioxide in the air in the photosynthetic process of leaves and on the mode of growth of plants. Proc. Roy. Soc. (London) B **70**: 397–413. 1902.

(5) Brown, Horace T. and T. Escombe. A new method for the determination of carbon dioxide, based on the rate of its absorption by

a free surface of a solution of caustic alkali. Proc. Roy. Soc. (London) Series B 76: 112–117. 1905.

(6) Brown, Horace T. and F. Escombe. On the variations in the amount of carbon dioxide in the air in Kew during the years 1898–1901 Proc. Roy. Soc. (London) series B 76: 118–121. 1905.

(7) Brown, Horace T. and F. Escombe. Researches on some of the physiological processes of green leaves, with special reference to the interchange of energy between the leaf and its surroundings. Royal Soc. (London) Proc. B 76: 29–111. 1905.

(8) Brown, W. H. and G. H. Heise. The relation between light intensity and carbon dioxide assimilation. Philippine Journal of Science. C. Bot. 12: 85–95. 1917.

(9) Brown, W. H. The theory of limiting factors. Philippine Journal of Science. C. Bot. 13: 345–350. 1918.

(10) Darwin, F. Observations on stomata. Phil. trans. Roy. Soc. (London) B 190: 531–621. 1898.

(11) Dastur, R. H. Water content, a factor in photosynthesis. Ann. of Bot. 38: 779–788. 1924.

(12) Dastur, R. H. and B. L. Desai. The relation between water-content, chlorophyll-content and the rate of photosynthesis in some tropical plants at different temperatures. Ann. Bot. 47: 69–98. 1933.

(13) Ewart, A. J. Assimilatory inhibition in plants. Jour. Linn. Soc. Bot. 31: 364–461. 1896.

(14) Heinicke, A. J. and M. B. Hoffman. The rate of photosynthesis of apple leaves under natural conditions. Part I. Cornell University Agricultural Experiment Station Bul. 577: 1–32, November, 1933.

(15) Heinicke, A. J. and M. B. Hoffman. An apparatus for determining the absorption of carbon dioxide by leaves under natural conditions. Science 77: 55–58. 1933.

(16) Heinicke, A. J. The assimilation of carbon dioxide by apple leaves as affected by ringing the stem. Amer. Soc. Hort. Sci. Proc. 29 (1932): 225–229. 1933 b.

(17) Iljin, V. S. Relation of transpiration to assimilation in steppe plants. Journal of Ecology 4: 65–82. 1916.

(18) Irving, A. A. The beginning of photosynthesis and the development of chlorophyll. Ann. Bot. 24: 805–818. 1910.

(19) Magness, J. R. and J. R. Furr. Stomatal activity in apple leaves. Amer. Soc. Hort. Sci. Proc. 27 (1930): 207–211. 1931.

(20) Matthei, Gabrielle L. C. Experimental researches on vegetable assimilation and respiration. III. On the effect of temperature on carbon dioxide assimilation. Roy. Soc. (London) Phil. trans. B 197: 47–705. 1905.

(21) McLean, F. T. Field studies of the carbon dioxide absorption of coconut leaves. Ann. Bot. 34: 367–389. 1920.

(22) Muskell, E. J. Experimental researches on vegetable assimilation and respiration. 18. The relation between stomatal opening and assimilation. A critical study of assimilation rates and porometer rates in leaves, in cherry laurel. Roy. Soc. (London) Proc. B 102: 488–533. 1928.

(23) Spoehr, H. A. Photosynthesis, p. 1–393. 1926.

(24) Stiles, Walter. Photosynthesis, p. 1–268. 1925.

ILLUSTRATIONS

PLATE 1. A general view of the apparatus, showing some of its parts.

FIG. A. Assimilation chamber, made of cellophane paper.
FIG. B. Gauge and scales, graduated in liters.
FIG. C. Respiratory tank made of iron.
FIG. D. Table or stand for the respiratory tanks.
FIG. E. Pulley made of wood.
FIG. F. "Arms" made of 12-mm. glass tubings, fitted in a bamboo pole.
FIG. G. Receptacle tank, made of iron. This tank has a capacity more or less the same as that of the respiratory tank.

PLATE 2. A close-up view of the apparatus showing some of its parts in detail.

FIG. A. U-tube for collecting the moisture resulting from transpiration.
FIG. B. Reservoir flask, consisting of 500-cc. Erlenmeyer Pyrex glass, provided with side neck for connections.
FIG. C. Absorption tower, consisting of thick glass tubings, about 60 cm. long and 2.5 cm. in diameter.
FIG. D. Dehydrating bottle of about 100 cc. capacity, containing concentrated sulphuric acid.
FIG. E. Capillary tube.
FIG. F. Home-made mannometer consisting of small glass tubings, about 4-mm. bore, and having U-shapes.
FIG. G. Scale, consisting of a foot rule graduated in centimeters.

PLATE 1.

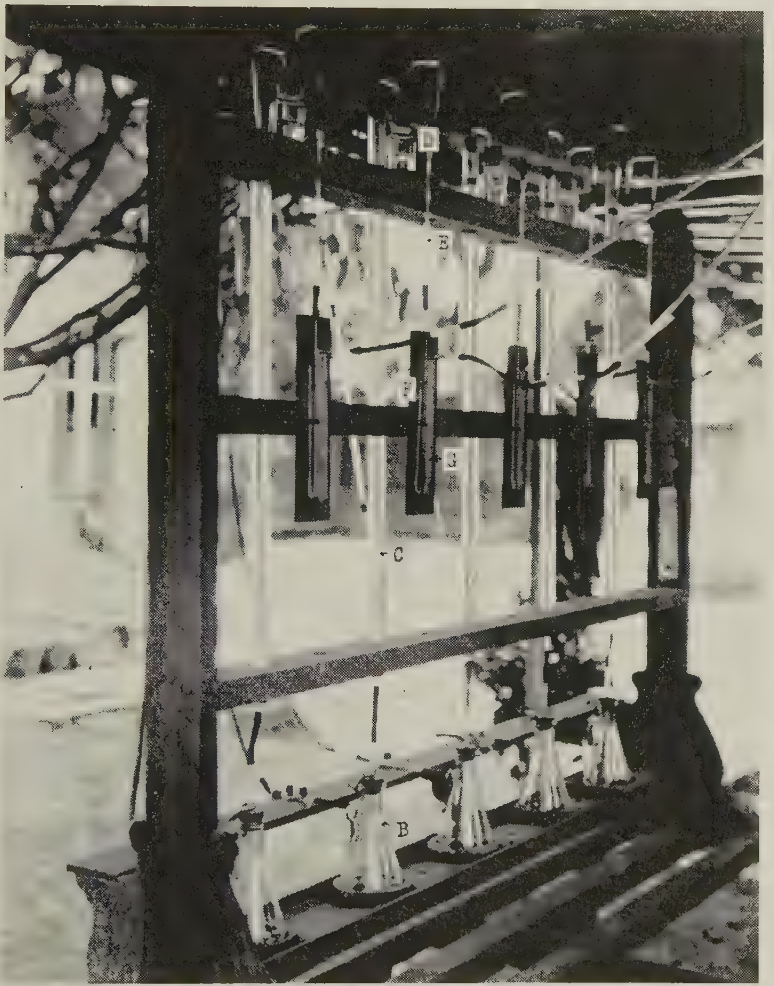


PLATE 2.

TRIAL PLANTINGS OF IRISH POTATO

By P. A. RODRIGO and P. S. URBANES
Of the Horticulture Section, Bureau of Plant Industry

FIVE PLATES

This paper deals with the results of the trial plantings of Irish potato, *Solanum tuberosum* L., at the Lipa Coffee-Citrus Station, Lipa, Batangas Province, from 1933 to 1936, inclusive. The increasing demand for more information on the culture of the Irish potato, especially at medium elevations, and the desire to find new regions suited to its cultivation with the ultimate aim of reducing our half-million-peso annual importation, have encouraged the writers to undertake this study.

The main object of the work is to find the possibility of growing Irish potato at Lipa, a plateau with an elevation of about 1,050 feet above sea level. The other object is to determine whether or not off-season crops of Irish potato could be raised. (The regular season for the culture of Irish potato is from November to February or during the cool months of the year.) Present indications point out that off-season planting is one of the keys to the solution of the local potato seed problem since the harvest of the main crop has been found not to store well for the next regular planting season. As it is now, most of the seed tubers planted are imported. The seed in potato culture, especially when imported, is a big item of expense, and in many cases makes the growing of the crop rather prohibitive.

MATERIALS AND METHODS

In this study, several varieties of Irish potato purchased from the local market and from abroad were tested. Table 1 shows the varieties tested and the country of origin.

TABLE 1.—*Showing the varieties of Irish potato tested and the country of origin*

Variety name	Seed house where secured	Country of origin
Japanese White	Local grocery	Japan.
Japanese Red	Local grocery	Japan.
Chinese Red	Local grocery	China.
Burbank	Local grocery	United States.
Oregon	Local grocery	United States.
May Queen	Sutton and Sons, Ltd	Great Britain.
Ben Lomond	Sutton and Sons, Ltd	Great Britain.
Glasgow Favourite	Sutton and Sons, Ltd	Great Britain.
Inverness Favourite	Sutton and Sons, Ltd	Great Britain.
Commander	Sutton and Sons, Ltd	Great Britain.
The Congo	Sutton and Sons, Ltd	Great Britain.

DESCRIPTION OF VARIETIES

It is not the aim here to give a botanical description of the different varieties studied. Rather, only the important agronomical characters are given to enable one to recognize a variety more or less readily upon close examination.

Ben Lomond.—An English variety. As grown in the Philippines, the haulm is stout but rather spreading, attains a height of about 45 to 60 centimeters, and the foliage is dark green and rather curly. The tubers are round to short kidney in shape with rather shallow eyes (Plate 4, *2*); skin and flesh white; and quality good. The distinguishing characteristic of this variety, however, is its tendency to produce numerous small tubers at every node including those immediately above the surface of the soil.

Burbank.—Of United States origin. The plant is characterized by a rather fine haulm although with the tendency to be erect; the foliage is light green. The tubers with distinct markings are elongated with rather shallow eyes, light brown in color with white flesh (Plate 2, *2*).

Chinese Red.—This variety matures in 80 to 85 days. The plant is rather dwarf with stout stem. The tuber is more or less round and light red. Very susceptible to soft rot.

Commander.—Of English origin. The haulm is of upright habit with semi-drooping foliage which is light green. It has the tendency to have numerous small tubers. The tuber is round to oblong, white, with eyes comparatively shallow.

Glasgow Favourite.—From England. The stem is generally erect, and the foliage is light green. The tuber is white-fleshed, and is more or less round to oval, eyes rather shallow (Plate 3, *2*). Fine table quality.

Inverness Favourite.—An English variety, and one of the two most promising among those tested. The healthy upright haulm is distinct in appearance; the foliage is dark green; and the white-skinned tubers with shallow eyes are oblong to oval. (Plate 5, *1*.) The tubers keep well in storage, and the cooking quality is excellent.

Japanese Red.—Of Japanese origin. A vigorous grower. It matures in 100 to 110 days, the latest to mature among the varieties tested. The haulm is stout and erect; the tubers which are round or spherical are generally borne on long peduncles especially in friable soil. The tuber is light red although the inside is white. Its eating and keeping qualities are poor. Rather deep-eyed.

Japanese White.—A Japanese variety which is the most popularly grown in Baguio. The haulm is rather erect but with spreading foliage. The tuber is oval to oblong with rather shallow eyes (Plate 3, *1*). As the name indicates, the skin and flesh are white; the quality is fine.

May Queen.—Of English origin and one of the two most productive among those tested. The haulm is comparatively upright but the foliage has the tendency to spread. The tuber is oblong to kidney in shape but is generally thicker on one side. The eyes are shallow, the skin is flesh white, and the appearance is very neat (Plate 2, *1*). The eating and keeping qualities are excellent.

Oregon.—Of United States origin. The plant is comparatively vigorous, and the haulm is erect. The tuber is spherical. White-skinned and fleshed, and the eyes are rather shallow (Plate 4, *1*).

The Congo.—A salad variety from England. The plant is erect with distinct dark foliage. The nether surface of the leaf is darker than the upper surface, and the veins are more prominently dark. The tubers which are purple flesh, small and much elongated, and the eyes are rather deep and numerous.

CULTURES

Six sets of planting were made, two sets during the rainy season, and four during the dry season. Table 2 gives the dates of planting and harvesting of the different sets of culture, and also the number of days from planting to harvesting.

TABLE 2.—*Showing the date of planting and harvesting of the different sets of culture*

Culture	Date planted	Date harvested	Number of days to mature
A	December 13, 1933	March 10–14, 1934	86–90
B	August 11, 1934	October 19–29, 1935	69–79
C	January 9, 1935	April 9–12, 1935	90–93
D	June 2, 1935	August 14–26, 1935	73–85
E	November 13, 1935	February 4, 1936	83
F	February 18, 1936 [1]		

[1] This culture, because of late planting, was very poor and data on maturity and yield are not included.

In Culture A, seven varieties, namely, Japanese White, Chinese Red, Burbank, Oregon, May Queen, Glasgow Favourite, and Ben Lomond were tested. These were new introductions

and for convenience were called foreign seed tubers. The first generation of the above varieties were used in Culture B. In Culture C, new seed tubers (foreign seed tubers) of Burbank, May Queen, Japanese White, Glasgow Favourite, Commander, Inverness Favourite, Japanese Red, and The Congo, and the second generation of Japanese White, May Queen, Burbank, Glasgow Favourite, Oregon, and Ben Lomond were used. In Culture D, the first and third generations of Oregon and Ben Lomond were used. For Culture E, the second and fourth generations of May Queen, Glasgow Favourite, Burbank, and Japanese White, and second generation of Oregon were used. In Culture F the foreign seed tuber, the second and fourth generations of May Queen, Inverness Favourite, Commander, Glasgow Favourite, and Burbank were tested.

With the exception of Culture A which was conducted between one-year old orchard trees behind the residence of the Superintendent of the Station, all the tests were done in the vegetable experimental field of the Lipa Coffee-Citrus Station. The soil was comparatively shallow, ranging in depth from 30 to 40 centimeters, and was underlaid with adobe soil. It was, nevertheless, fairly uniform, and had a very gentle slope, ensuring good drainage during the rainy season.

In all plantings, the fields were thoroughly prepared with the use of the native plow and harrow. Furrows were made at 80 centimeters apart and the potato seeds were planted singly at 30 centimeters apart in the rows. All the cultures were fertilized with nitrophoska containing 16.5 per cent nitrogen, 16.5 per cent P_2O_5, and 20 per cent K_2O (16.5—16.5—20) at the rate of 450 kilograms per hectare. The fertilizer was evenly broadcasted in the furrows and then thoroughly mixed with the soil before planting.

The usual method of planting Irish potato was followed in all plantings. The big tubers were sliced into two or more pieces depending upon their sizes. Those from two to three centimeters in diameter were planted as whole tubers. To minimize any error due to soil variation, the varieties were planted in single rows and were repeated two or more times depending upon the amount of seed tubers available. In each set of planting, the different varieties were given practically the same cultural treatments up to maturity. These treatments consisted of cultivation, weeding, irrigation, spraying, etc.

In all cultures, the weight of the total yield, and that of the marketable tubers of the unit row or plant were taken. Tubers with a diameter of 4 centimeters or more were considered marketable and those below were considered as culls. In Cultures A, B, and E, a single plant was used as the unit in gathering experimental data, while in the rest of the tests (Cultures C and D), the row was considered as the unit.

EXPERIMENTS AND RESULTS

Culture A.—This culture took place from December, 1933, to March, 1934. The season was considered ideal for the growing of potato, and, as a result, a good stand of crop was obtained (see Plate 1, Figs. 1 and 2). Seven varieties were studied in this test. Table 3 presents a summary of the results of this culture.

TABLE 3.—*Showing the comparative yields of seven newly introduced Irish potato varieties at the Lipa Coffee-Citrus Station from December 13, 1933, to March, 1934.*

Variety name	Generation of seed [1]	Actual yield per plant		Computed yield per hectare (marketable)
		Total	Marketable	
		Grams	*Grams*	*Kilos*
May Queen	F	339.68 ± 5.54	329.67 ± 5.48	13,738
Glasgow Favourite	F	222.39 ± 4.46	208.60 ± 4.65	8,692
Burbank	F	223.81 ± 3.85	208.39 ± 3.63	8,650
Japanese White	F	267.77 ± 4.79	259.60 ± 4.77	10,817
Oregon	F	248.90 ± 4.47	239.45 ± 4.57	9,979
Ben Lomond	F	358.04 ± 5.56	273.88 ± 4.76	11,413
Chinese Red	F	195.35 ± 5.06	186.05 ± 5.13	7,754

[1] F means foreign or introduced seed tubers.

Culture B.—This was undertaken during the rainy season of 1934 from August to October. The first generation of the varieties used in the first culture was used with the exception of Chinese Red. Separate plantings of small and big tubers were made. The results show that the big but sliced seed tubers had much lower percentage of germination than the small whole seed tubers. Because of the comparatively excessive rainfall before germination, a high percentage of the sliced tubers failed to germinate. The stand of the crop was, at best, fair. Quite a high percentage of the tubers produced were big enough for planting purposes. Table 4 presents a summary of the results of this phase of the study.

TABLE 4.—*Showing the comparative yields of small and big seed tubers when planted during the rainy season*

Variety name	Kind of seed tuber	Per cent stand	Average yield per plant		Computed yield per hectare (marketable)
			Total	Marketable	
			Grams	*Grams*	*Kilos*
May Queen	big	54	185.15±11.57	168.82±11.52	3,798
May Queen	small	74	197.44± 8.79	111.70± 5.21	3,444
Glasgow Favourite	big	14	136.70±15.64	106.60±14.20	622
Glasgow Favourite	small	59	145.39± 6.93	69.37± 4.33	1,706
Burbank	big	59	158.12± 7.04	144.85± 7.24	3,562
Burbank	small	72	127.52± 5.21	113.74± 5.02	3,418
Japanese White	big	20	240.23±19.64	221.86±18.64	1,849
Japanese White	small	35	167.30± 9.46	150.46±10.45	2,191
Oregon	big	32	152.00±10.03	139.75± 9.46	1,864
Oregon	small	77	189.74± 7.11	175.96± 7.16	5,864
Ben Lomond	big	51	197.39±11.44	128.02± 8.80	2,720
Ben Lomond	small	61	233.60± 8.21	154.54± 8.21	3,927

Culture C.—The results of this culture are presented in Table 5. The culture was undertaken from January, 1935, to April of the same year. The planting was rather late, and the crop was confronted with the effects of the dry season. The strong dry wind then prevalent greatly affected this culture. The stand of the crop was very poor compared with that of the previous year (Culture A). In this culture, an attempt was made to compare the yielding ability of the Lipa grown seed tuber (second generation) and the imported seed tuber. Newly imported varieties were also included in the cultures.

TABLE 5.—*Showing the compartive yields of Lipa grown and imported seed tuber (dry season culture)*

Variety name	Generation of seed tuber [1]	Actual yield of 18-sq m. plots		Computed yield per hectare (marketable)
		Total	Marketable	
		Kilos	*Kilos*	*Kilos*
May Queen	F_2	4.91±0.45	4.43±0.46	2,494
May Queen	F	6.11±0.44	5.75±0.44	3.237
Glasgow Favourite	F_2	3.70±0.32	2.80±0.17	1,577
Glasgow Favourite	F	7.60±0.54	7.19±0.53	4,049
Burbank	F_2	4.97±0.41	4.44±0.39	2,500
Burbank	F	6.17±0.42	5.76±0.41	3,243
Japanese White	F_2	2.24±0.06	2.02±0.30	1,137
Japanese White	F	4.26±0.15	4.03±0.15	2,269
Oregon	F_2	2.52±0.27	2.38±0.28	1.340
Ben Lomond	F_2	4.74±0.17	2.79±0.95	1,571
Commander	F	6.58±0.69	5.43±0.69	3,057
Japanese Red	F	3.88±0.38	3.68±0.36	2,072
Inverness Favourite	F	9.18±0.49	8.60±0.46	4.843
The Congo	F	2.24±0.24	1.95±0.24	1.098

[1] F_1 means foreign or introduced seed tubers. F_2 means second generation.

Culture D.—This culture took place during the rainy season of 1935 from June to September. Ten varieties were included in the test. The seed tubers used were Lipa grown and they represented first and third generations of several varieties. Small and big seed tubers were again compared. Table 6 gives a summary of the results obtained. As in a previous rainy season test, the sliced seed tubers had very poor percentage of germination. Many plants died because of the severe attack of Solanaceous wilt.

TABLE 6.—*Showing the comparative yields of small and big seed tubers of first and third generations*

Variety name	Generation of seed tuber [1]	Big seed tuber (sliced)		Small seed tuber (whole)	
		Number of hills planted	Average yield per plant (marketable)	Number of hills planted	Average yield per plant (marketable)
			Grams		*Grams*
May Queen	F_1	8	73.0	57	132
May Queen	F_3	27	150	50	154
Glasgow Favourite	F_1	0	Few germinated	24	109
Glasgow Favourite	F_3	0	Few germinated	17	79
Burbank	F_1	0	Few germinated	2	128
Burbank	F_3	0	Few germinated	10	43
Japanese White	F_1	0	Few germinated	5	73
Japanese White	F_3	0	Few germinated	4	156
Oregon	F_3	2	120	5	247
Ben Lomond	F_3	0	Few germinated	7	92
Inverness Favourite	F_1	0	Few germinated	47	140
Commander	F_1	5	106	49	159
The Congo	F_1	0	Few germinated	4	48
Japanese Red	F_1	0	Few germinated	0	Few germinated

[1] F_1 means first generation, and F_3 refers to third generation.

TABLE 7.—*Showing the comparative yields of second and fourth generations of different varieties of Irish potato*

Variety name	Generation of seed tuber [2]	Average yield of 13-sq. m. plot		Computed yield per hectare (marketable)
		Total	Marketable	
		Kilos	*Kilos*	*Kilos*
May Queen	F_2	10.44 ± 0.34	9.68 ± 0.29	7,446
May Queen	F_4	10.94 ± 0.39	10.22 ± 0.36	7,862
Burbank	F_2	4.91 ± 0.46	4.37 ± 0.48	3,362
Burbank	F_4	4.31 ± 0.07	3.95 ± 0.24	3.038
Glasgow Favourite	F_2	7.64 ± 0.39	6.91 ± 0.36	5,315
Inverness Favourite	F_2	13.44 ± 0.30	12.59 ± 0.27	9,685
Commander	F_2	10.67 ± 0.28	5.06 ± 0.28	3,892
The Congo	F_2	1.86 ± 0.48	1.24 ± 0.36	954
Japanese White [1]	F_4	2.80	2.36	1,815
Oregon [1]	F_4	2.88	2.60	2,000

[1] Because of the lack of seed tuber only one replication was made.
[2] F_2 means second generation and F_4 refers to fourth generation.

Culture E.—This culture was one of the best in stand and in yield in the whole series. The culture was held from November, 1935, to February, 1936. Eight varieties were included in the test and, besides comparing the yielding ability of the different varieties, an attempt was also made to compare the productivity of the second and fourth generations of seed tubers. Tables 7 and 8 present the summary of the results of this study.

TABLE 8.—*Showing the comparative yields of small and big seed tubers of four varieties of Irish potato*

Variety name	Kind of seed tuber	Average yield of 13-sq. m. plot (marketable)	Computed yield per hectare
		Kilos	*Kilos*
May Queen	Big	11.06 ±0.18	8,508
May Queen	Small	9.72 ±0.12	7,477
Burbank	Big	4.06 ±0.32	3.123
Burbank	Small	5.11 ±0.12	3,931
Inverness Favourite	Big	12.70 ±0.54	9,769
Inverness Favourite	Small	12.49 ±0.47	9,615
Commander	Big	4.70 ±0.37	3,923
Commander	Small	5.42 ±0.36	4,169

Culture F.—In this culture, an attempt was again made to compare the yielding powers of Lipa grown potato seed tuber (second and fourth generations) and the imported seed tuber. Due to the delayed arrival of the foreign seed tuber, the culture was started during the early part of February, 1936. As a result, the stand of the crop was very poor because of dryness and the prevalence of dry wind. It was deemed necessary, therefore, not to include in this report the data obtained.

TABLE 9.—*Comparative yields of different varieties of Irish potato for a period of three years*

Variety name	Average yield per hectare (dry season culture)			
	1933–34	1934–35	1935–36	Average
	Kilos	*Kilos*	*Kilos*	*Kilos*
May Queen	13,738	2,866	7,659	8,088
Glasgow Favourite	8,692	2,813	5,315	5,607
Burbank	8,650	2,872	3,200	4,907
Japanese White	10.817	1,703	1,815	4,778
Oregon	9,979	1,340	2,000	4,440
Ben Lomond	11,413	1,571	----------	6,492
Chinese Red	7,754	----------	----------	7,754
Commander	----------	3,057	3,892	3,475
Japanese Red	----------	2,072	----------	2,072
Inverness Favourite	----------	4,843	9,685	7,264
The Congo	----------	1,098	954	1,026

Table 9 was prepared so as to have an idea of the average yielding power of the different varieties tested during the regular planting season (dry season). This table is a summary of Tables 3, 5, and 7.

DISCUSSION OF RESULTS

Some definite information on the possibility of growing Irish potato at the Lipa Coffee-Citrus Station and its vicinity have been obtained. In general, dry season plantings showed some possibilities for the commercial growing of Irish potato in that region. Rainy season cultures were full of risk because of uncertain weather conditions but when the planting was made at a time that was not followed by a continuous rain, it also showed some possibilities for the production of good-sized tubers for planting purposes during the regular planting season which, in Lipa and its vicinity, is from November to early part of January.

VARIETIES TESTED

As seen in Table 1, eleven varieties of Irish potato, six from Great Britain, two from the United States, two from Japan, and one from China, were tested in connection with this study. These varieties were tested for a period from one to three years. The average computed yield per hectare of the dry season cultures of these varieties is summarized in Table 9. A study of Table 9 shows that May Queen and Inverness Favourite were the most productive and, therefore, seem to be the best adapted to Lipa conditions among the eleven varieties studied. The average yield of May Queen was 8,088 kilograms per hectare for a period of three years, and it ranged from 2,866 kilograms in 1934–35 when the planting was late to 13,738 kilograms per hectare in 1933–34 when the planting was made in December and conditions were more favorable. The average yield of Inverness Favourite was 7,264 kilograms per hectare for a period of two years and the range varied from 4,843 to 9,685 kilograms per hectare. It is interesting to note that during the last two years when these two varieties were cultured together, Inverness Favourite outyielded May Queen (see Table 9). Both of these varieties have attractive appearance and good storing quality (see Plate 2, fig. 1 and Plate 5, fig. 1). Their eating qualities are also excellent. They mature in 85 to 100 days depending upon the season of the year at the time of planting.

Of the less productive but nevertheless promising varieties may be mentioned Glasgow Favourite with an average yield of

5,607 kilograms per hectare; Burbank, with a three-year average yield of 4,907 kilograms per hectare; Japanese White, with a three-year average yield of 4,778 kilograms per hectare; and Commander, with a two-year average yield of 3,475 kilograms per hectare. The Commander variety, while it has a lower average yield than either Burbank and Japanese White (see Table 9), has an average yield during the last two years greater than those of either Burbank and Japanese White.

It may also be noted in Table 9 that Chinese Red and Ben Lomond had comparatively high yields—higher than anyone of those considered promising varieties. It may be stated here, however, that Chinese Red was tested for only one year (Culture A) and it was the poorest in that test. Its storing quality was also the worst. Ben Lomond, on the other hand, while it was the second best in yield in 1933–34, did not produce well in the succeeding years. Besides, it showed an undesirable characteristic—the production of small and numerous tubers at every node, including those immediately above the soil. The Congo, because of the small size of the tubers, is naturally a poor yielder. Under local conditions where there is no demand yet for varieties especially adapted to salad making, the The Congo, because of its very low yield and poor keeping quality, has no prospect.

SMALL VERSUS BIG TUBERS FOR SEED

An attempt was made to find the value of small tubers (20 to 35 grams in weight) and big tubers for planting purposes. Tables 4 and 8 present the results of the tests. A study of both tables will show that the yielding power of small and big tubers varied with the different varieties. As seen in Table 4, four of the six varieties tested showed that the big tubers yielded more than the small tubers although in one case the difference was not significant. In the case of Oregon and Ben Lomond, the small seed tubers produced more than the big seed tubers, but it was only in the case of the first variety where the difference may be considered mathematically significant.

In the dry season culture (see Table 8) the big seed tubers yielded more in the case of May Queen and Inverness Favourite, but less in the case of Burbank and Commander. The differences, however, were not significant except in the case of Burbank. From present appearances it seems that the size of the seed tubers (within certain limit) does not materially affect the yielding power of the plants produced. The results, in general,

tend to corroborate the findings of Hutcheson and Wolfe [1] who reported that 1-ounce (28.3 grams) "cuts" had practically the same yield whether such "cuts" were either sliced or small (whole) seed tubers. It seems that the more important consideration is the vitality of the seed tuber when planted.

RAINY SEASON TEST

The percentage of the stand of the crop during the rainy season was rather low, especially in the case of the big but sliced seed tubers. The stand of the crop from the big but sliced seed tubers varied from 14 to 59 per cent among the six varieties tested, while in the case of the small (whole) seed tubers, the stand varied from 35 to 77 per cent. It was evident that under wet soil conditions, the sliced seed tubers were more subject to rotting than the whole tubers, thus resulting in lower percentage of germination and poorer stand of the crop.

The tubers produced during the rainy season tests were small as compared with those produced during the dry season (see Plate 5, fig. 2). They were, however, big enough for seed purposes. As seen in Table 4, the computed yield per hectare of the four best varieties varied from 1,864 to 5,864 kilograms. These yields are rather low as compared with those of the dry season cultures. The results, nevertheless, point out the possibility of growing Irish potato during the rainy season to supply the seed tuber for the main crop in November to early part of January.

It should be remarked in here that in connection with Irish potato culture in the Islands, the question of seed tuber is one, if not the most important limiting factor of production. This is especially so when the seed tuber is purchased. However, as aided by favorable market conditions its culture here may be made more profitable if the seed tuber is produced by every grower.

As already stated, the main handicap in growing potato during the rainy season is the rather poor stand of the crop due to low percentage of germination, and in some cases, its total failure because of unforeseen inclement weather. This disadvantage, however, may be minimized by setting the seed tubers at the proper time, that is, to plant when heavy and continuous rains are not likely to occur. If the seed tubers are set in when the soil is not liable to be soaked, the germination would be high.

---

[1] Hutcheson, T. B., and T. K. Wolfe. Potato culture. Virginia Agric. Expt. Sta. Bull. No. 217 (1917).

From experience, one can more or less tell the best time to set in seeds in a certain locality. In Lipa, at least, potato may be safely planted during May or the early part of June and in the early part of August. Planting in May and June seems to be about the best because of the fact that potato planted at this time can be harvested a few months before the regular planting season in November and December, thus giving the new harvest enough time to be seasoned out or cured before they are planted. It may be mentioned here that newly harvested tubers do not germinate readily when planted; it takes from two to three months after harvest before the tubers attain normal germination. August planting seems to be rather late.

PHILIPPINE GROWN VERSUS IMPORTED SEED TUBER

In the 1934–35 and 1935–36 dry season cultures, an attempt was made to compare the yielding power of the Lipa grown seed tuber and imported seed tuber. Results of the first test are presented in Table 5; in the second test due to late planting because of the delayed arrival of the foreign seed, the culture was a failure. A study of Table 5 shows that of the four varieties tested, namely, May Queen, Glasgow Favourite, Burbank, and Japanese White, the imported seed tuber was decidedly superior in yielding power to the Lipa grown seed tuber. It may be stated in this connection that judging from appearances, the imported seed tubers were newer and more vigorous than the Lipa grown seed tuber, and as a result, the stand of the plants was better in the plots planted with the former seed. However, it may also be mentioned that in the 1935–36 dry season culture of Lipa grown seed, the stand of plants and the yield thereof were comparable to those of the 1933–34 culture of imported seed (see Tables 3 and 7). This goes to show that wherever possible, it would seem more economical to raise the potato seed tuber locally.

SUMMARY AND CONCLUSIONS

From the results presented in this paper, the following conclusions seem to be justified:

1. The conditions of Lipa, Batangas (the elevation is 1,050 feet above sea level), have been found to be adapted to the growing of Irish potato. The yield per hectare of a number of varieties tested varied from 954 to 13,738 kilograms. With the four best varieties, the yield varied from 2,813 kilograms per hectare during the lean years to 13,738 kilograms during good years.

2. Of the eleven varieties tested for a period of two to three years, May Queen and Inverness Favourite were the two most productive varieties, the average yield being 8,088 and 7,264 kilograms per hectare, respectively. The less productive, but nevertheless, promising varieties were Glasgow Favourite, Japanese White, Burbank, and Commander.

3. Based on the performance of the two best yielding varieties (May Queen and Inverness Favourite) the months of November and December have been found to be the best time to plant Irish potato at the Lipa Plateau. In the 1933–34 season, the sowing was made in December and the yield of May Queen was 13,738 kilograms per hectare; in 1934–35 the planting was made in November and the respective yields of the two above mentioned varieties were 7,659 and 9,685 kilograms per hectare.

4. While the results for two years on the comparative study of the value of small (whole) seed tubers (20 to 35 grams in weight) and sliced big tubers (above 35 grms. in weight) were in favor of the big seed tubers, the difference was not very significant. However, during the rainy season tests, the small seed tubers (planted whole) had a decided advantage over the big seed tubers (sliced) as they were less subject to decay.

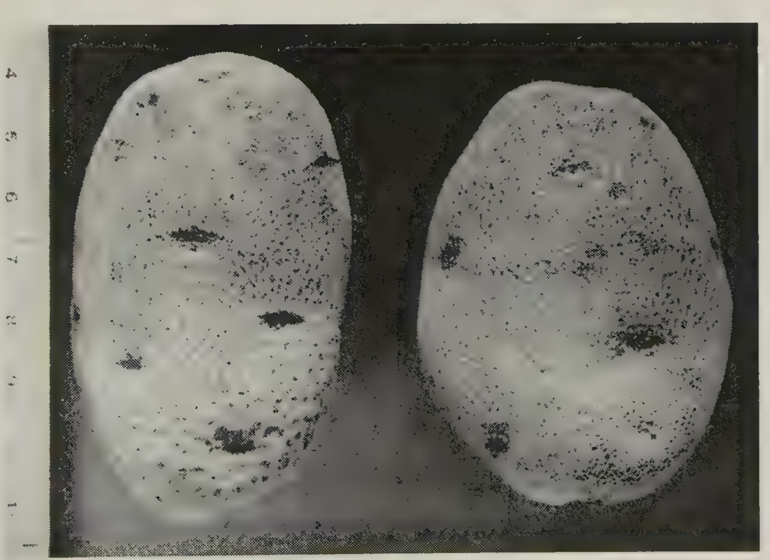
5. Rainy season cultures did not behave as well as the dry season cultures. The general stand of the crops both in percentage and in appearance was much inferior to that of the dry season cultures. The seed tubers planted were subject to decay before germination, especially when the soil was soaked soon after planting. However, when the seed tubers were able to germinate before the continuous rain came, the behaviour of the crop was better. Some varieties gave yields as high as from 3,444 to 5,864 kilograms per hectare during the rainy season test. The tubers produced were comparatively small but were large enough for seed purposes.

6. In a study where Lipa grown seed tuber was compared with imported seed tuber in yielding quality, it was found that the imported seed tuber was decidedly better than the local grown seed tuber. It is significant to note, however, that the second and fourth generations of seed tubers planted in November, 1935, gave comparable yields to the imported seed tubers planted in 1933–34.

ILLUSTRATIONS

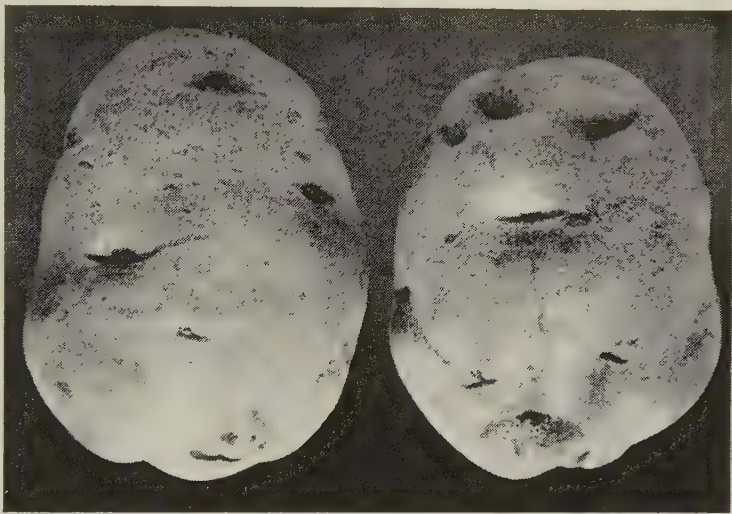
PLATE 1.

1

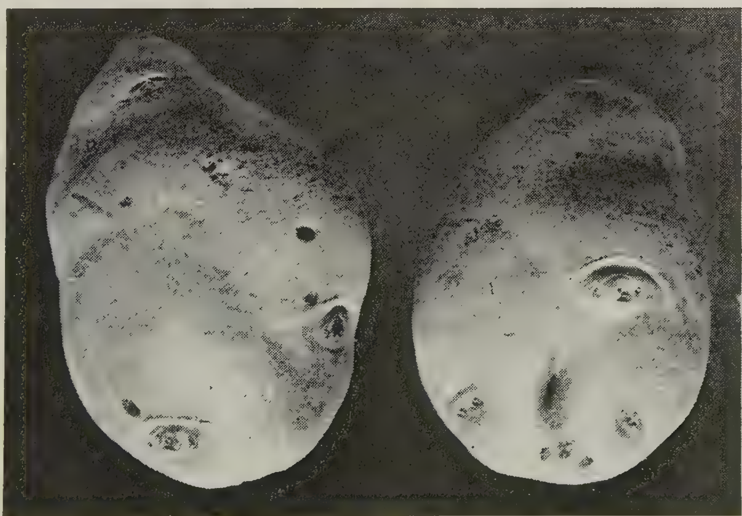


2

PLATE 2.

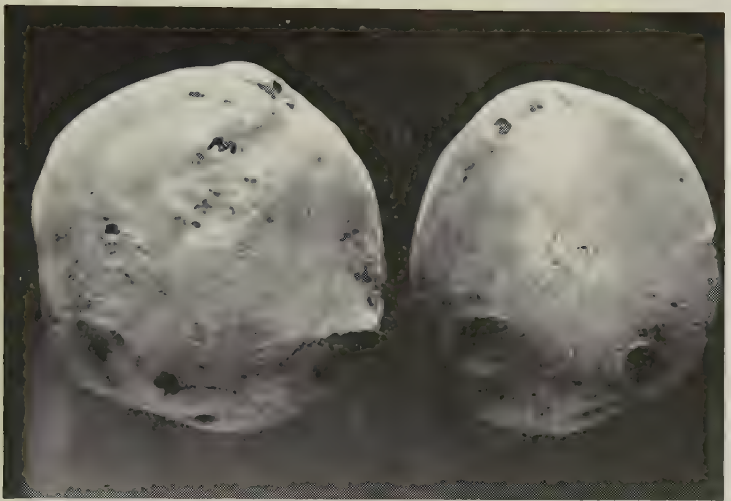


1

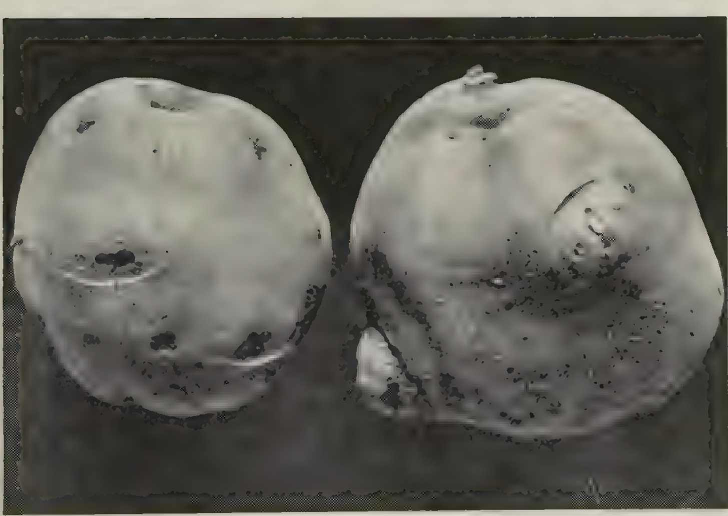


2

PLATE 3.

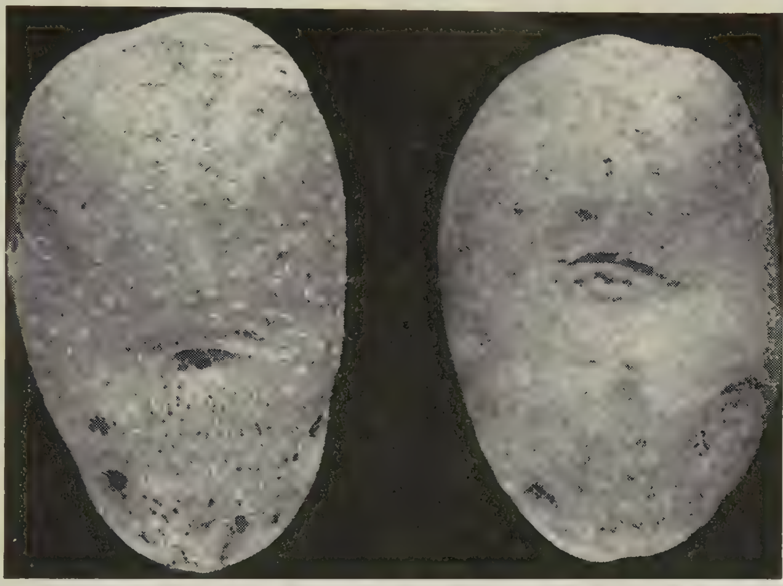


1

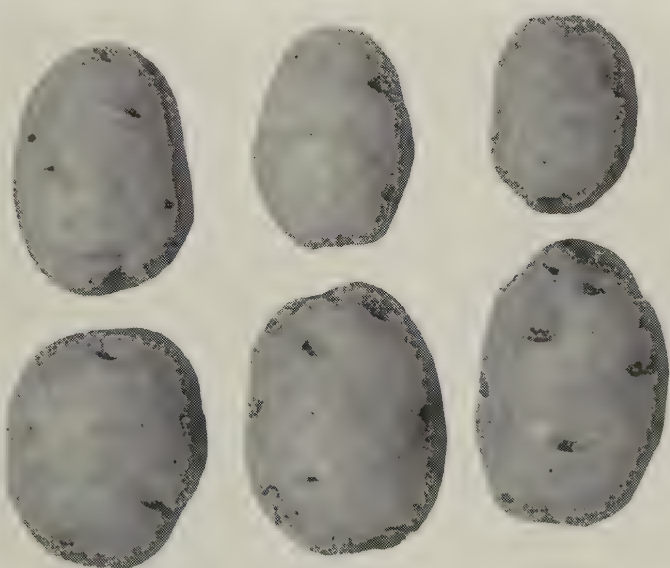


2

PLATE 4.



1



2

PLATE 5.

THE TOMATO LEAFMOLD (*CLADOSPORIUM FULVUM* CKE.), A NEW SERIOUS DISEASE OF TOMATO IN BAGUIO, MOUNTAIN PROVINCE

By T. G. FAJARDO[1]
Of the Bureau of Plant Industry

TWELVE PLATES

INTRODUCTION

The tomato leafmold, *C. fulvum* Cke., which is a serious leaf disease of glasshouse-grown tomatoes in the United States and in other temperate countries was noted for the first time in Baguio,[2] Mountain Province, in 1934. It appeared in the glasshouse of the Baguio Plant Industry Experiment Station on both American and native tomatoes toward the end of the fruiting season when few plants showed the typical lesions, which resulted in the yellowing, curling, or drying up and falling of the leaves. The following season, the disease became more general and affected the plants in their early stages. Those which were severely attacked were stunted, or died prematurely, while those that were able to survive lost almost one-half to three-fourths of their leaves, so that their yield was greatly reduced, and the fruiting season very much shortened.

Because of the scarcity and high price of tomatoes, especially during the rainy season, the culture of this crop commercially under glasshouses might prove to be a profitable enterprise in Baguio and in other parts of the Philippines with identical climate. Since the leafmold disease is likely to become an important disease of tomatoes grown under glasshouses, and in the field as will be discussed later, a preliminary report of our observations of the disease are hereby presented for the interest

[1] The writer is grateful to Lt. Juan P. Tecson, who was formerly with this Bureau, for his assistance in some observations herein reported in this paper.

[2] Baguio has an elevation of over 4,000 feet above sea level and the climate is generally uniformly cool throughout the year. Because of this favorable semi-temperate climate, extensive culture of vegetables are grown from which several thousand pesos are ralized every year.

of prospective glasshouse tomato growers particularly in the vicinities of Baguio.

GEOGRAPHIC DISTRIBUTION AND ECONOMIC IMPORTANCE

In the United States(1), (5), (6), (7), (10), (11), (16), (17), and other temperate countries (2), (3), (8), (9), (12), (13), the leafmold disease is well known. It is generally serious on tomatoes in glasshouses in the northern States which are not provided with adequate heating and ventilating system, while in Florida(16) and other sections of the southern States it is regarded primarily as a field disease of tomato. In the Philippines, this malady was observed in Baguio, and under certain conditions it becomes very serious in the glasshouse [3] (Plate 1) and in the field.

The annual loss due to it has not been actually determined, but during the rainy or cooler and moister months it becomes epiphytotic and spreads rapidly in the glasshouse, causing within a few days many leaves to turn yellow and fall off. Because of the loss of the leaves, which results into a greatly weakened condition of the plants, the yield is materially reduced due to failure of some fruits from reaching their normal size, or failure of the fruits from becoming set. If the infection is severe when the plants are young, such plants may be stunted or die prematurely, and if infection occurs when the plants are already full grown or have already fruited, slight to no reduction of yield may be noted.

The writer is not aware just how this disease got into the Philippines; but since it is known to be seed borne(5), it is probable that it might have been introduced with the infected seeds, and since it was not observed during the survey of garden crop diseases in this region(4), it is also believed that its introduction into this region is very recent.

GENERAL SYMPTOMS

The tomato is susceptible to the disease at any stage of growth and the leaves, flowers, fruits, and even the succulent stems are attacked. The greatest damage, however, occurs on the leaves where infection usually starts on the lower ones close to the ground and then gradually spreads upward until one-half

[3] The glasshouse at the Experiment Station has a glass roof and glass sides, but it is not provided with mechanical devices with which to regulate the heat and humidity as is found in modern glasshouses in temperate countries.

to nearly all are affected. Later on, these affected leaves turn yellow, dry up and finally drop off (Plates 2 and 3), or dry up and curl rapidly but remain attached to the stem so that these infected plants appear as if they were swept by fire.

The lesions on the leaves usually start as a small whitish downy patch of fungus growth on the lower surface (Plate 4, fig. 1 and Plate 6, fig. 2). Under favorable conditions, as this downy patch enlarges the advancing edge retains its whitish color, while the center becomes light brown to dark velvety brown due to the production of abundant spores of the causal organism (Plate 4, fig. 3 and Plate 5, figs. 1 and 2). On the upper surface of the leaves opposite this fungus growth, the tissues become light green to yellowish green color (Plate 4, fig. 2 and Plate 6, fig. 1), and from these areas the spores of the fungus may be also produced (Plate 4, fig. 2). These yellowish green tissues also increase in size as larger areas become invaded by the fungus and sooner or later such tissues die and form dark brown dead spots of varying sizes and shapes, sometimes involving the whole leaf area (Plate 4, fig. 2 and Plate 6, fig. 1).

The flowers and fruits are also attacked by the disease (5) and (6). On the flowers, the calyx as well as the other parts are also affected, with the production of dark velvety growth of the causal fungus. Because of this infection, the flowers sooner or later die and fall off before the fruits are set. Examination of infection on the flowers, however, should be carefully made so that the effect of such infection would not be confused with that produced by other organisms such as tiny bugs. The symptoms on the fruits are very characteristic, and according to Gardner(5) it causes conspicuous black stem end rot of both immature and ripe greenhouse tomatoes.

CAUSAL ORGANISM

The causal fungus is a member of the Dematiaceæ, of the large group of fungi—Fungi imperfectii. The mycelium and the fruit bodies are colored. The conidia are elliptical to oblong, 1 to 2 septate, and are borne on the tip of the conidiophores. According to Stevens(14) they vary in sizes from 10 to 20 by 4.0 to 6.0 microns, but from our measurements, they are from 12.9 to 27.2 by 6.8 to 11.2 microns, showing that the spores of the species here reported are slightly bigger but are closely within the range of sizes given by Stevens. The conidiophores are sparingly branched, septate, and arise at the stomatal opening of the leaves. They are from 54.4 to 204.0 by 3.4 to 8.5

microns. Plate 7 shows the spores and conidiophores of *C. fulvum* Cke., from diseased tomato leaf from the glasshouse.

GERMINATION OF SPORES

The spores do not readily germinate under dry conditions, but in the presence of sufficient moisture they germinate within a few hours in the glasshouse, in the laboratory, or in the open under shade. In a series of experiments conducted during September, sample of spores suspended in 5 cc. of tap water, or in 5 cc. of 2 per cent sugar solution gave 89.4 and 98.5 per cent germination, respectively, after 24 hours. In these experiments, a hanging drop from each of these germinating solutions with spores was placed in a series of van Tieghem cells, and then exposed for 24 hours under laboratory conditions in Baguio with temperatures ranging from 17° to 22° C. In order to keep them moist, the slides were placed in moist petri dishes, the bottom of which were covered with two layers of moist filter papers.

TABLE 1.—*Germination of C. fulvum spores under various conditions in Baguio*

Environment under which the spores were allowed to germinate	Duration of observation [a]	Per cent germination	Length of germ tubes in microns	
			Range	Average
	Hours			
Laboratory conditions	4	21.6	3.4– 15.3	9.6
	8	87.0	10.2– 34.0	19.5
	12	94.4	37.4– 68.0	50.5
17°—20° C.	24	97.3	40.8–105.4	65.7
	30		([b])	([b])
Average—18.5° C.				
Glasshouse conditions	4	23.5	3.5– 23.8	9.6
	8	82.2	6.8– 51.0	27.5
	12	89.8	10.2– 61.0	35.1
17°–22 C.	24	92.8	40.8–112.0	72.9
	30		([b])	([b])
Average—20° C.				
Outside conditions	4	4.9	3.4– 6.8	5.1
	8	16.3	3.4–17.0	7.6
	12	16.6	6.8–20.4	12.2
16°–20° C.	24	86.8	20.4–71.4	39.4
Average 17.5° C.	30	93.3	20.4–80.2	44.1

[a] At the time this experiment was conducted, it was generally cloudy in the morning, rainy at noon until afternoon, and foggy at night.

[b] Branching profusely after 30 hours.

Using identical methods as above, another series was conducted, with 2 per cent sugar solution used as the germinating medium. Series of hanging drops in van Tieghem cells were made and exposed in the laboratory, in the glasshouse, and in the shade outside. The results which are summarized in Table 1 show that germination took place even after 4 hours, and 24 hours later the percentage of germination from all these sets of conditions was high. In this study it was also observed that the rate of germination and the elongation of germ tubes of those kept in the laboratory and in the glasshouse was much faster than those left in the open under shade.

The results obtained show that the spores germinated readily under these sets of conditions in Baguio with temperatures ranging from 16° to 27° C., and are in accord with the results of Gardner(5) and Makemson who found that spore germination in water is best at temperatures between 18° to 24° C., a similar range of temperature generally found in Baguio. Plate 7 shows the germinating spores of *C. fulvum* Cke., after 4, 8, 12, and 24 hours.

LONGEVITY OF SPORES

The spores are known to remain viable for a few months to one year(5) and (10). In a series of experiments, spores were scraped off from fresh infected leaves, then put in petri dishes, and were allowed to desiccate in the glasshouse and in the laboratory for 15, 20, 30, and 45 days. After each time interval, sample of spores were suspended in 2 per cent sugar solution and the percentage of germination was determined after 48 hours. As shown in Table 2 the percentage of germination was greatly reduced after 45 days. This result was further confirmed by another series of experiments in which infected leaves with heavy sporulations were desiccated in the glasshouse and in the laboratory as mentioned above, showing that the spores are still viable after 45 days, the longest period tried. No attempt was made to determine how long the spores would survive, but because of the ideal semi-temperate climate of Baguio (Table 3) and from what is already known on the viability of the spores, they might live long enough in our glasshouse to cause infection from one tomato season to the next, as will be discussed herein.

TABLE 2.—*Longevity of spores of C. fulvum Cke. in the glasshouse and in the laboratory in Baguio*

Duration of dessication	Glasshouse conditions		Laboratory conditions	
	Number of pores observed	Percent germination after 48 hours	Number of pores observed	Percent germination after 48 hours
Series I [a]				
20 days	150	83.6	105	85.6
30 days	105	25.7	125	15.1
45 days	347	18.3	172	41.8
Check [c]	----------	----------	100	51.0
Series II [b]				
20 days	207	51.2	99	26.2
30 days	334	13.1	126	5.1
45 days	565	4.9	235	1.3
Check [c]	----------	----------	269	43.9

[a] Spores were scraped off the leaves and placed in petri dishes.

[b] Infected leaves with heavy sporulations were placed in petri dishes.

[c] Spóres were obtained from fresh diseased leaves of growing tomato plants in the glasshouse.

INFECTION EXPERIMENTS

In a series of experiments, 6 potted young tomato plants were inoculated by applying spores in suspension on both sides of the leaves by means of an atomizer. After inoculation, the plants were placed in an improvished moist chamber for 24 hours, and then placed in the glasshouse, in the shade outside, and in the open without shade, by placing two plants to each set of conditions. After 10 days, infection was noted on the plants left in the glasshouse, while those left outside developed their symptoms after 15 days. In another set, six plants were again inoculated, but after inoculation they were placed in the open without shade and in the glasshouse. After 20 days, all became infected and the disease was noted to have already spread to the younger upper leaves (Plate 8).

In the last series, two healthy plants growing outside near the laboratory and six plants in the glasshouse were inoculated on September 19, 1936, and one plant growing in the field was inoculated on September 28. Again, all these plants became infected after two weeks. The infected plants in the glasshouse were then transplanted in the field. These, together with the other plants outside, continued to be infected when the final notes were made in December. The result of these ex-

periments showed that the tomato plants growing in the field or glasshouse became readily infected with the leafmold disease, but the lesions which developed on plants left in the glasshouse were more extensive and with heavier sporulations than from those observed from the field at this time of the year when these studies were made.

SEASONAL OCCURRENCE OF THE DISEASE IN THE GLASSHOUSE

In Baguio the disease appears in the glasshouse at any time of the year as long as there are tomato plants growing. It becomes more prevalent and serious during the rainy season or cooler and moister months of the year, i. e., July, August, and September, when severe losses may be experienced, but during the summer months, i. e., March, April or other drier months, the disease becomes less serious, so that a fairly good crop may be harvested. It is not known how long the fungus may persist in the glasshouse after infected vines have been pulled out, but in a series of plantings made in the glasshouse natural infection was still noted after the tomatoes have not been grown from 4 to 8 months, indicating that the fungus is still viable to cause infection from one tomato season to the next.

SEASONAL OCCURRENCE OF THE DISEASE IN THE FIELD

The tomato leafmold is generally a glasshouse disease, but under Baguio climate it develops normally, and under certain conditions it may become as serious on tomatoes in the field as those noted in the glasshouse. In a series of tests slightly infected plants from the glasshouse of Burpee's Self Pruning, Break O'Day, Chalk's Early Jewel, Marglobe, Stone, Golden Queen, and Burpee's Matchless tomato varieties were set in rows into an isolated Plant Pathology plot on January 9, 1936. When notes were made after 1½ months from the date of planting, typical lesions with abundant sporulations were noted, and later on the disease spread to the upper leaves. The malady, however, became less prevalent during March and April when the weather was much warmer and drier, but it persisted on these plants until June.

No attempt was made to determine whether or not the disease could survive all the year round in the open field in Baguio, but from our experiments it may persist as long as there are growing tomato plants, since infected plants left outside with or without shade during the rainy months or during the

other drier months continued to have the disease until the plants were killed by another but more aggressive tomato disease caused by *Phytophthora infestans* (Mont.) de Bary.[4]

INFLUENCE OF ENVIRONMENT ON DISEASE DEVELOPMENT

The fungus was shown by various authors(10), (12), (15) to be greatly influenced by temperature and humidity of the air in order to produce the disease. Small(12) found that the optimum temperature for various stages of leafmold is about 22° C, and that at 10° and 15° C severe infection occurs under humid condition, but the disease develops slowly. He further found that the humidities of the air exceeding 90 per cent are very favorable. At 22° C, which is the optimum temperature, infection in severe when the humidity is at 80 per cent, but rare at 70 per cent, while at 18° C infection and subsequent development are considerably retarded at 80 per cent humidity. No attempt was made to study the relation of temperature and humidity to disease development, but, from Table 3 which shows the monthly average minimum and maximum relative humidity and temperature of the air in Baguio for 5 years, it can be seen that the climatic conditions of this mountain region is favorable at any time of the year for the development of the disease, with more serious consequences occurring during the rainy months of the year when the humidities of the air outside and in the glasshouse becomes very high.

LIFE HISTORY OF FUNGUS IN RELATION TO DISEASE PRODUCTION

Aside from the spores which may survive the unfavorable period in the glasshouses, the fungus is also known to tide over by forming from the dead infected tissues sclerotial-like or perithecial-like structures from which the conidiophores and conidia are produced when the conditions become more favorable. The conidia or spores which are produced usually first infect the lower leaves by penetrating through the stomata. The fungus soon after entering establishes its parasitic habit, spreads through the tissues and in a few days produces the typical lesions on the leaves. From these lesions abundant spores are produced and the disease is further spread to the other leaves, or to other plants in the glasshouse by wind, by splashing

[4] The late blight disease, caused by *Phytophthora infestans* (Mont.) de Bary is generally serious under field conditions in Baguio, but it does not usually appear in our glasshouse which has much warmer temperature than outside field conditions.

of water during watering, or they may be transported to other sections of the glasshouse with the soil, with the infected vines, or by clinging with the working tools, clothings, and hands, so that in a few weeks time, the leaves of every plant may be all affected.

TABLE 3.—*The average monthly maximum and minimum temperatures and relative humidities of the air in Baguio for the years 1932–1936* [a]

Month	Temperatures			Relative humidities		
	Average maximum	Average minimum	Average	Average maximum	Average minimum	Average
January	22.06	12.50	17.28	94.04	65.70	79.87
February	22.00	13.80	17.90	92.98	65.44	79.21
March	23.20	13.80	18.50	94.01	67.32	80.66
April	23.84	13.16	18.50	95.56	70.42	82.99
May	23.56	15.84	19.70	95.96	77.00	86.48
June	23.16	15.53	19.34	97.88	78.18	88.03
July	21.50	15.52	18.50	98.48	83.50	90.99
August	21.90	15.40	18.60	98.12	81.78	89.95
September	22.32	15.60	18.96	97.08	82.32	89.70
October	22.32	15.16	18.74	97.22	78.06	88.14
November	22.64	14.40	18.50	95.42	71.52	83.47
December	22.46	13.90	18.18	91.32	68.62	79.97
Total	270.96	174.61	222.70	1,148.07	889.86	1,019.46
Average	22.58	14.55	18.56	95.67	74.15	84.95

[a] The data herein reported were obtained through the courtesy of the Baguio Observatory, Weather Bureau.

While the initial infection of the season may start from spores which are able to tide over, these sclerotial-like structures formed from the diseased tissues which are also noted in Baguio, or the mycelium on the infected seeds are, however, potential in carrying the disease over from one tomato season to another or transporting the malady from one locality to another.

SUSCEPTIBILITY OF TOMATO VARIETIES TO LEAFMOLD

As far as known, nearly all the commercial varieties of tomato, *Lycopersicum esculentum* L., are susceptible to the leafmold disease(1), (8), (11), but the degree of susceptibility varies with the different varieties. Jagger(8) and Small(11) tested several varieties and found Stirling Castle, Up-to-Date, Norduke, Main Crop, Satisfaction, and Frogmore as only partially resistant. Alexander(1) in his recent study also found that, of the 180 varieties tested, the above mentioned varieties were listed as partially resistant, while the Red Currant tomato, *L. pimpinellifolium* Dunal, was resistant. In our test, 20 varieties of

both American and native tomatoes were all found susceptible, with the Native, Oblong, Chalk's Early Jewel, Stone, Break O'Day, Marglobe, Burpee's Matchless, Burpee's Tangerine, Burpee's Self Pruning, and Burpee's Trucker's Favorite less affected than the other varieties. Table 4 shows the relative susceptibility of different tomato varieties to the leafmold disease.

PROGRESS ON SELECTION OF TOMATO RESISTANT TO LEAFMOLD

Since all these varieties are susceptible, attempts were made at selection of resistant strains from those which were found to do well in the glasshouse. In this study, unless otherwise stated, the seeds of different commercial tomatoes were planted in short rows in the glasshouse bench, and when they were 7 to 8 inches high the two most vigorous seedlings were transplanted

TABLE 4.—*Relative susceptibility of tomato varieties to leafmold, C. fulvum Cke.*

Name of varieties	Seedling plants[a]			Mature plants[b]		
	Number of seedlings observed	Percent infected	Remarks on leafmold infection[c]	Number of plants observed	Percent infected	Remarks on leafmold infection
Native No. 1, small fruited	40	100	+	2	100	+—
Native No. 2, big fruited	44	100	++	2	100	+
Oblong	38	100	+	2	100	+
Yellow plum	15	100	+	2	100	++
Red Pear				2	100	++
Sunnybrook Earliana	50	100	+++	2	100	++
Spark's Earliana	28	100	+++	2	100	+++
Penn State Earliana	33	100	++	2	100	++
Golden Dwarf Champion	27	100	++	2	100	++
Golden Queen	43	100	++	2	100	++
Chalk's Early Jewel	14	100	+	2	100	+
June Pink	31	100	+++	2	100	++
Stone	46	100	+	2	100	+
Burpee's Fordhook First	43	100	+	2	100	++
Burpee's Matchless	17	100	+	2	100	+
Burpee's Tangerine	39	100	++	2	100	+
Burpee's Self Pruning	33	100	++	2	100	+
Burpee's Trucker's Favorite	30	100	++	2	100	+
Break O'Day	23	100	+	2	100	+
Marglobe	36	100	+	2	100	+

[a] Seedlings were grown in short rows in the glasshouse.

[b] The mature plants were grown in the glasshouse bench and leafmold infection was observed from time to time.

[c] + —, trace to slight infection; lesions prominent, sporulation slight: + slight to serious infection; lestions prominent, sporulation quite abundant: + + serious infection; lesions prominent, sporulation dense and a number of leaves dry up: + + + Very serious infection; lesions very prominent, sporulation very dense, and many leaves turn yellow, dry up and fall off.

in permanent rows, spaced at 70 to 75 cm. between the rows and 50 cm. between the plants. In some cases, the seeds were first started in seed boxes, the seedlings were pricked at 8 to 10 cm. apart, and later the two best plants of each variety or "strain" were transplanted in permanent bench in the glasshouse as mentioned above. In these studies the plants were all exposed to natural infection, and notes on the disease were made throughout the season. As an index on resistance or susceptibility, the type of lesion, density of sporulation, the per cent of yellowing and drying up of the leaves, and the yield were taken into consideration. At the end of the season, the seeds of the high yielding, more "resistant strains" were saved and planted during the next tomato season, while the poor yielding and more susceptible ones were either eliminated or planted again as an index of resistance on the selected strains, and also served as a source of inoculum for the disease.

TABLE 5.—*Observation on the relative susceptibility of tomatoes to leafmold, C. Fulvum Cke.*

Name of varieties	Number of plants observed	Number of fruits produced	Remarks on leafmold infection[a]
Native—R29-8-1	2	65	+ —
Burpee's Matchless	1	3	+ —
Burpee's Tangerine	1	30	+ —
Burpee's Self Pruning	1	13	+ —
Burpee's Trucker's Favorite	2	17	+ —
Burpee's Fordhook First	1	8	+ +
Marglobe	2	7	+ —
Break O'Day	2	20	+ —
Chalk's Early Jewel	2	30	+ —
Golden Dwarf Champion	2	23	+
June Pink	2	14	+ —
Sunnybrook Earliana	1	13	+ +
Spark's Earliana	1	7	+ +
Penn State Earliana	1	6	+ +
Yellow Plum	2	44	+ +
Red Pear	2	75	+ —

[a] — absent to trace; + — trace; + slight to serious; + + serious; + + + very serious.

Series 1.—In this first series, samples of seeds from all the varieties were planted in short rows, and when the seedlings were 8 to 10 inches high the best two plants were planted in the glasshouse bench. In this trial, leafmold appeared late and infection was slight, so that a fair yield was gathered. As shown in Table 5, the Native, Burpee's Matchless, Burpee's Tangerine, Burpee's Self Pruning, Burpee's Trucker's Favorite, Mar-

globe, Break O'Day, Chalk's Early Jewel, June Pink and Red Pear were slightly affected. Because of apparent resistance and prolificacy, the Native, Burpee's Matchless, Burpee's Tangerine, Burpee's Self Pruning, Marglobe, Break O'Day, and Chalk's Early Jewel were selected as "promising strains," or varieties.

Series 2.—In this series, seeds from "promising strains" or varieties mentioned above were planted in short rows on October 22, 1934. As check, nine other unselected varieties were also planted. On December 2, the best two plants were transplanted in the bench and each plant was given a number, as No. 1 and No. 2 selections of the variety. Leafmold infection was noted early in the season, but because the weather was less favorable at this time, the disease did not become serious until the plants were in the flowering and fruiting stages. The result which are summarized in Table 6 show that the selections from the Native, Burpee's Matchless, Burpee's Self Pruning, Marglobe, Stone, Chalk's Early Jewel, June Pink, Spark's Earliana, Penn State Earliana, and Golden Queen produced a total average weight of fruits ranging from over a kilo to over two kilos depending upon the "strain," while poorer yield was obtained from the other varieties. In this connection, it will also be noted that generally all No. 1 plants yielded higher than the No. 2 plants of the same selection and planted in the same bench. This difference was perhaps due to the fact that the No. 1 plants were planted near the aisle where there was more free air circulation than those of No. 2 plants which were planted near and along the side of the glasshouse. In the more "resistant" strains, however, the location of planting did not greatly affect their yield as those noted of the more susceptible strains.

Series 3.—In this series, seeds of plants No. 1 from Burpee's Self Pruning, Marglobe, Break O'Day, and June Pink together with some of the high yielding strains from Series 2, were sown in short rows in the glasshouse on June 15, 1935. The best two plants were again transplanted on July 24. This planting coincided with the rainy season, and in about one month from date of planting the lower leaves of most of the varieties were already affected. The disease became very serious that in less than three weeks' time nearly all the leaves were affected and, sooner or later, many leaves turned yellow, dried up, and fell off, or remained attached to the plants. From Table 7, in spite of the severe infection, Burpee's Self Pruning yielded

better, while the other strains, either succumbed earlier or if they survived their yields they were greatly reduced.

TABLE 6.—*Observation on the relative susceptibility of tomatoes to leafmold, C. Fulvum Cke.*

Name of varieties	Total fruits harvested	Total weight of fruits	Average weight of fruits	Average size of fruits	Remarks on leafmold infection [a]
		Grams	*Grams*	*Cm.*	
Native:					
Plant 1	53	2,320.0	43.8	4.2	+
Plant 2 [b]	30	1,243.0	41.4	4.0	+
Plant 5	30	1,786.0	59.5	5.0	+
Burpee's Matchless:					
Plant 1	34	2,383.0	70.1	5.0	+
Plant 2	9	657.0	73.0	5.0	+
Burpee's Tangerine:					
Plant 1	9	566.0	62.9	4.4	+—
Plant 2 [c]					
Burpee's Self Pruning:					
Plant 1	18	1,661.0	92.3	5.3	+
Plant 2	20	1,253.0	62.6	4.5	+
Marglobe:					
Plant 1	14	1,554.0	111.0	5.5	+—
Plant 2	13	971.0	74.7	4.17	+—
Break O'Day:					
Plant 1	15	1,201.0	80.1	4.7	+
Plant 2	10	469.0	46.0	3.7	+
Chalk's Early Jewel:					
Plant 1	19	1,155.0	60.8	4.6	+—
Plant 2	21	1,152.0	54.8	3.0	+—
Burp. Truck Favorite:					
Plant 1	7	866.0	123.7	6.5	+—
Plant 2	0				+—
Burpee's Fordhook First:					
Plant 1	28	1,057.0	37.7	3.6	++
Plant 2	11	391.0	35.5	3.3	++
Stone:					
Plant 1	23	1,464.0	64.6	4.7	+—
Plant 2	20	1,023.0	46.5	4.2	+—
June Pink:					
Plant 1	23	1,525.0	66.3	4.8	+
Plant 2	20	1,305.0	65.2	4.5	+
Golden Queen:					
Plant 1	53	2,926.0	55.2	4.3	++
Plant 2	13	810.0	62.3	4.6	++
Golden Dwarf Champion:					
Plant 1	23	968.0	42.0	3.7	++
Plant 2	20	966.0	48.3	3.8	++
Sunnybrook Earliana:					
Plant 1	18	1,194.0	66.3	5.1	++
Plant 2	9	656.0	76.2	4.8	++
Spark's Earliana:					
Plant 1	21	1,275.0	60.7	4.5	++
Plant 2 [c]					++
Penn State Earliana:					
Plant 1	35	2,309.0	66.0	4.5	++
Plant 2	18	721.0	40.0	3.5	++

[a] +— trace; + slight to serious; ++ serious +++ very serious.
[b] Native No. 5 planted near the ailse on the other end of the glasshouse.
[c] Infected with mosic and the plant was pulled off.

TABLE 7.—*Observation on the relative susceptibility of tomatoes to leafmold, C. Fulvum Cke.*

Name of varieties	Total fruits harvested	Total weight of fruits	Average weight of fruits	Remarks on leafmold infection [a]
		Grams	*Grams*	
Burpee's Self Pruning:				
Plant 1	10	840.0	84.0	++
Plant 2 [b]				
Marglobe Plant:				
Plant 1	2	125.0	62.5	++
Plant 2	2	115.0	57.5	++
Break O'Day:				
Plant 1	2	213.0	106.5	++
Plant 2 [b]				
June Pink:				
Plant 1	6	160.0	26.6	+++
Plant 2 [b]				
Sunnybrook Earliana:				
Plant 1	4	213.0	53.2	+++
Plant 2	4	210.0	52.5	+++
Penn State Earliana:				
Plant 1	0			+++
Plant 2 [b]				
Golden Dwarf Champion:				
Plant 1	1	40.0	40.0	+++
Plant 2 [b]				

[a] ++ serious; +++ very serious.

[b] Severely affected and pulled off before the fruits were set.

Series 4.—In this series, seeds of the high yielding No. 1 plants of Burpee's Self Pruning, Break O'Day, and Marglobe which showed very well in the last series were planted again on December 5, 1935. As check and for further observation on the other varieties, Chalk's Early Jewel, Burpee's Matchless, Golden Queen, Stone and Native were also planted. On January 4, 1936, six plants of each of the selected Burpee's Self Pruning, Break O'Day, and Marglobe strains were planted on one of the benches, and given selection numbers from 1 to 6, while two plants of each of the other unselected strains were planted in the other bench, and were also given numbers from 1 to 2. As shown in Table 8 the selections Nos. 1 to 5 of Burpee's Self Pruning (Plates 9 and 10) and plants Nos. 1 and 2 of Break O'Day (Plate 11) yielded satisfactorily with each plant giving a total weight of fruits ranging from 1,126 grams to 1,798 grams. The other varieties, even if leafmold was not very serious this season, yielded very poorly (Plate 12).

Series 5.—In this experiment, seeds of selections Nos. 1 to 6 of Burpee's Self Pruning, Selections No. 1 and No. 2 of Break O'Day and Selection No. 2 of Marglobe from the above series

were planted on May 1, 1936. The seedlings were pricked and on June 24, the best two plants of each selection were planted on the bench. As check, Golden Queen, Native, and an unselected Burpee's Self Pruning from the field were also planted. On August 4, leafmold infection was noted on the lower leaves of the Golden Queen, Native and Marglobe varieties. As the weather continued to be rainy during this time of the year, the environment in the glasshouse became so favorable that the disease spread very rapidly. Within three weeks time, from one-half to nearly all the leaves were infected, with the more susceptible Golden Queen, and the unselected Burpee's Self Pruning strain from the field more seriously attacked.

As shown in Table 9 the yield of the selections were greatly reduced, and in some cases no fruit was harvested. It will be observed also, that in some instances even the best selections obtained from the last series of the Burpee's Self Pruning failed to produce any fruit. This was not due all to leafmold, but partly due to nematode infection on the roots which resulted

TABLE 8.—*Observation on the relative susceptibility of tomatoes to leafmold, C. Fulvum Cke.*

Name of varieties	Total fruits harvested	Total weight of fruits	Average weight of fruits	Average size of fruits	Remarks leafmold infection [a]
		Grams	*Grams*	*cm.*	
South bench					
Burpee's Self Pruning:					
Selection 1	23	1,798.5	78.2	5.6	+—
Selection 2	30	1,407.5	46.9	4.4	+—
Selection 3	24	1,126.0	46.9	4.4	+—
Selection 4	21	1,144.2	54.5	4.8	+
Selection 5	26	1,630.7	62.7	5.0	+—
Selection 6	24	979.4	40.8	4.1	+—
Break O'Day:					
Selection 1	13	1,759.3	135.3	6.9	+
Selection 2	24	1,714.0	71.4	5.2	+
Selection 3	3	169.0	56.3	5.0	+
Selection 4	2	175.0	87.8	6.0	+
Marglobe:					
Selection 1	6	642.0	107.0	6.2	+
Selection 2	10	784.0	78.4	5.7	+
North bench					
Native:					
Plant 1	19	890.0	46.8	5.0	+—
Plant 2	10	389.1	38.9	5.0	+
Stone:					
Plant 1	11	921.5	83.8	5.9	+
Plant 2	9	1,036.0	115.1	6.6	+

[a] +— Trace to slight infection.

TABLE 8.—*Observation on the relative susceptibility of tomatoes to leafmold, C. Fulvum Cke*—Continued.

Name of varieties	Total fruits harvested	Total weight of fruits	Average weight of fruits	Average size of fruits	Remarks on leaf-mold infection [a]
		Grams	*Grams*	*Cm.*	
Golden Queen:					
Plant 1	11	615.0	55.9	4.9	+—
Plant 2	8	377.5	47.2	4.9	+—
Burpee's Matchless:[b]					
Plant 1	2				++
Plant 2	1				++
Chalk's Early Jewel:[c]					
Plant 1	0				+++
Plant 2	0				+++

[a] +— Trace to slight infection; ++ serious; +++ Very serious.

[b] This variety is late maturing and only 3 green fruits were harvested on May 21, when the final notes were made.

[c] The plants were badly diseased with leafmold and powdery mildew and were pulled out early in the season.

in poor, stunted growth of the plants,[5] and the other reason was due to a certain insect which attacked the flowers and caused many of them to blight and drop off before the fruits are set.

From the results of these series mentioned above no variety or "strain" has been selected so far which is immune or highly resistant to the leafmold disease. The selections from Burpee's Self Pruning which in all these trials appeared to be more resistant and yielded higher than the other varieties, became also seriously affected (Plate 2) when extremely high humidity existed in the glasshouse, which environment is very ideal for epiphytotic development of the disease. But even at this extremely favorable conditions, Burpee's Self Pruning selections were able to yield better (Plates 9 and 10), while the unselected susceptible strain failed to produce any fruit, or succumbed before the end of the season. Furthermore, these selections when planted during the drier months of the year, when the disease is less serious, may yield even as much as twice more than the unselected susceptible strains (Plates 9, 10, 11, and 12).

In this connection, the type of growth of the plants, earliness of fruiting and prolificacy have some bearing in escaping or avoiding the leafmold disease. In these trials, Burpee's Self Pruning selections have the tendency to grow more erect, pro-

[5] The nematode disease, *Heterodera radicicola* (Greef) Muller, became very general in the glasshouse soil, but, in spite of it, some of the varieties were able to produce their fruits.

TABLE 9.—*Observation on the relative susceptibility of tomatoes to leafmold, C. Fulvum Cke.*

Name of varieties [b]	Total fruits harvested	Total weight of fruits	Average weight of fruits	Remarks on leafmold infection [a]
		Grams	*Grams*	
Burpee Self Pruning S-1:				
Plant No. 1	0			+—
Plant No. 2	0			+
Burpee Self Pruning S-2:				
Plant No. 1	0			+—
Plant No. 2	0			+—
Burpee Self Pruning S-3:				
Plant No. 1	0			+—
Plant No. 2	0			+—
Burpee Self Pruning S-4:				
Plant No. 1	3	213.0	71.0	+—
Plant No. 2	1	45.0	45.0	+—
Burpee Self Pruning S-5:				
Plant No. 1	10	666.0	66.0	+—
Plant No. 2	12	872.0	72.7	+—
Burpee Self Pruning S-6:				
Plant No. 1	7	343.5	49.1	+—
Plant No. 2	1	26.0	26.0	+—
Burpee Self Pruning S-X:				
Plant No. 1	0			++
Plant No. 2	7	692.0	98.9	++
Break O'Day S-1:				
Plant No. 1	0			+
Plant No. 2	0			+
Break O'Day S-2:				
Plant No. 1	0			+—
Plant No. 2	1	55.5	55.5	+—
Marglobe S-2:				
Plant No. 1	2 [c]			+
Plant No. 2	1	124.0	124.0	+
Native:				
Plant No. 1	4	148.5	37.1	+—
Plant No. 2	2	73.0	36.5	+—
Golden Queen S-2:				
Plant No. 1	0			++
Plant No. 2	0			++

[a] +— trace to slight; + Slight to serious; ++ serious.
[b] Nematode infection on the roots were noted from all the varieties.
[c] Two small green fruits were harvested. This is a late variety.

duce few branches and flowers, mature their fruit earlier, and are more prolific. Because of these qualities they had more chances to set, mature or ripen their fruits before the disease became general and serious in the glasshouse in Baguio. In the absence of a better variety, and if tomatoes have to be grown in the glasshouses in Baguio, Burpee's Self Pruning selections may be planted until better or even an immune strain could be developed.

DISCUSSION AND SUGGESTION FOR CONTROL

The appearance of tomato leafmold, *C. Fulvum* Cke., in the Philippines, especially in Baguio, Mountain Province, where the climate is semi-temperate, is of scientific interest for this is the first record of it in the Philippines. Its becoming established or widespread in this region, however, is an added problem to vegetable growers considering that there are now so many plant diseases and plant pests problems which the farmers have to fight against. Fortunately, this malady is not yet widespread, nor has the culture of tomato under glasshouses become popular. Since this disease will likely become one of the limiting factors in the culture of tomato under glasshouses in Baguio, or in other regions with similar climate, the following control measures are suggested:

(1) Since the disease is greatly favored by temperatures between 20° to 22° C. and a relative humidity between 80 to 90 per cent or above, the glasshouses for tomato culture should be provided with adequate heating or ventilating system so as to maintain an environment below the requirements for the fungus to develop.

(2) Chemical fungicides for the control of this disease in the glasshouses have been recommended by various workers(2) (3) (6) (8) (14). According to Small(14), Ammonium copper carbonate, Colloidal Sulfur A and the Sodium Salt of Salicylanilide were found to be effective sprays, if Agral I [6] is added as spreader. Bewley and Orchard(2) reported excellent control with Salicylanilide paste or "Shirlan," combined with Agral I. Many writers, however, are not unanimous in recommending the use of sprays as a means of control, since the fungicides when applied could not cover the leaves thoroughly, and even at best, are not commercially successful.

(3) The control of the disease by fumigating an empty infected glasshouses before planting has been found very satisfactory and necessary in order to eliminate the disease. Small(14) obtained complete killing of spores in a glasshouse of 25,000 cubic feet capacity when fumigated with formalin (40 per cent) poured upon crystals of potassium permanganate at the rate of 1.25 pints of formalin plus .8 pound of potassium permanganate placed in 4 receptacles, or by the use of sulphur dioxide by burning flower of sulphur at the rate of 5 heaps of sulphur each of 5 pounds burned simultaneously. Magee(9)

---

[6] A sulphonated oil with a trade name known as Agral I.

also recommends fumigation with sulphur dioxide by using 10 pounds per 10,000 cubic feet burned in 5 or 6 heaps spaced at intervals in the receptacle in the floor of the glasshouse.

(4) The use of resistant varieties of tomato is the surest and cheapest means of control, if such varieties are in existence. At present, however, only partially resistant varieties are known, and these should be planted if found adaptable to local conditions. While no highly resistant or immune variety has been selected at present, our selections from Burpee's Self Pruning are recommended for glasshouse culture in place of other varieties which have been tested so far at this Station.

(5) Under Baguio conditions if tomatoes had to be grown in the glasshouse, and in the absence of resistant varieties, the planting should be made so that the crop does not coincide with the rainy or moister months of the year, thus avoiding the disease when it is most serious.

(6) In addition to these recommendations, strict sanitation and proper culture of plants in the glasshouses should be practised. Proper pruning of plants to induce thin growth, removal and burning of infected leaves or vines, and avoidance of excessive watering are very essential means of minimizing the occurrence and spread of the disease. Removal from the greenhouse and burning of infected vines after harvest should be followed from year to year so as to minimize the source of inoculum for initial infection from one crop of tomato to another.

SUMMARY

1. The tomato leafmold, *C. fulvum* Cke., which is a troublesome glasshouse disease of tomato in the United States and in other temperate countries was noted for the first time in 1934 in Baguio, Mountain Province, Philippine Islands.

2. This disease is not yet widespread, as it is only observed in the glasshouse of the Baguio Plant Industry Experiment Station.

3. The disease appears in the glasshouse at any time of the year, but becomes more destructive during the rainy or moister and cooler months when it spreads very rapidly and causes many leaves to turn yellow, curl up and finally drop off.

4. The writer is not aware how this disease got into the Philippines, but, it is believed that it might have been introduced, since it is known to be transmitted with the seeds.

5. The disease is due to a fungus parasite, *C. fulvum* Cke. The spores of the species reported are slightly bigger, but are within the range of sizes given by Stevens.

6. The spores germinate readily in the presence of moisture in the glasshouse, in the laboratory, or in the open with or without shade in Baguio.

7. Experiments showed that tomatoes are readily infected and develop their symptoms within 10 to 15 days after inoculation with spores.

8. The spores are easily disseminated, and if the conditions are favorable the disease is spread by means of spores to all the plants within a few weeks in the glasshouse.

9. The longevity of the fungus in the glasshouse was not determined. Natural infection, however, was noted after tomatoes have not been planted from 4 to 8 months, indicating that the fungus remained viable for that length of time in the glasshouse in Baguio.

10. The disease is generally a glasshouse disease of tomato, but it may also occur normally in the field and under certain conditions it may become very serious.

11. The fungus is known to survive inclement weather by means of spores or by forming sclerotia-like structures from the infected tissues. From these means it may be perpetuated from one planting season to another, or it may be transported from one locality to another.

12. The fungus is favored greatly by temperatures between 20° and 24° C., and relative humidities between 80 to 90 per cent or above. The climate of Baguio is ideal and it is believed that this disease might become one of the serious diseases of tomatoes in the glasshouse or in the field of this region.

13. Results of experiments show that all tomato varieties are susceptible to the disease. None of the varieties tested was found to be resistant or immune. Our selections from Burpee's Self Pruning were found better than the other varieties, and these may be grown in the glasshouse until better ones are found.

LITERATURES

1. ALEXANDER, L. J. Leafmold resistance in the tomato. Ohio Expt. Sta. Bull. **539**: 1–26. 1934.
2. BEWLEY, W. F. and O. B. ORCHARD. The control of tomato Leafmold. Ann. Appl. Biol. **19**: 185–189. 1932.
3. CHAMBERLAIN, E. E. Tomato leafmold (*Cladosporium fulvum*). New Zealand Jour. Agr. **45**: 136–142. 1932.

4. FAJARDO, T. G. Plant disease problems confronting truck farmers in Trinidad Valley and vicinity of Baguio, Mountain Province, P. I. Phil. Jour. Sci. **53**: 67–95. 1934.
5. GARDNER, MAX W. Cladosporium leafmold of tomato: Fruit invasion and seed transmission. Jour. Agr. Res. **31**: 519–540. 1925.
6. GREGORY, C. T. Controlling leafmold in greenhouses in Indiana. Ind. Acad. Sci. Proc. **37**: 382–385. 1927.
7. GUBA, E. T. Tomato leafmold. The use of fungicides for its control in greenhouses. Mass. Agr. Expt. Agr. Expt. Sta. Bull. **248**: 1–24. 1929.
8. JAGGER, I. C. Tomato mildew. Cheshunt Expt. and Res. Sta. Hertz Ann. Rept. **12**: 34. 1926. (Not seen.)
9. MAGEE, C. J. Tomato leafmold. A disease new to glasshouse crop in New South Wales. The Agr. Gazette of New South Wales **45**: 24–26. 1934.
10. NEWHALL, A. G. and J. D. WILSON. A preliminary report on forced air ventilation for the control of Cladosporium leafmold of greenhouse tomatoes. Phytopath. **19**: 83. 1929.
11. SMALL, T. The tomato leafmold. Cheshunt Expt. and Res. Sta. Hertz Ann. Rept. **13**: 40–51. 1928. (Not seen.)
12. ——— The relation of atmospheric temperature and humidity to tomato leafmold (*Cladosporium fulvum* Cke). Ann. Appl. Biol. **17**: 71–80. 1930.
13. ——— Experiments on the control of tomato leafmold (*C. fulvum* Cke) by fungicides and fumigants. Ann. Appl. Biol. **18**: 305–312. 1931.
14. STEVENS, F. L. Plant disease fungi. The MacMillan Company. 1925. New York.
15. WALKER, J. C. and C. B. SUMMER. Prevent tomato leafmold by lowering greenhouse humidity. Wisc. Agr. Expt. Sta. Ann. Rept. Bull. **421**: 66–67. 1932.
16. WEBER, G. F. and G. B. RAMSEY. Tomato diseases in Florida Univ. of Fla. Agr. Expt. Sta. Bull. **185**: 102–104. 1926.

ILLUSTRATIONS

PLATE 1

Glasshouse of the Baguio Plant Industry Experimental Station, where the leafmold disease was noted in 1934.

PLATE 2

Tomato plants (Burpee Self Pruning Selections) affected with leafmold disease *C. fulvum* Cke. showing the typical yellowing, drying and falling of the affected lower leaves. These plants were transplanted on June 24, 1936 and on August 4, leafmold was noted in the greenhouse. When notes were made on Sept. 19 nearly all the leaves were infected, and the lower leaves began to dry up and fall off. Photographed on September 19, 1936 when the plants were about three months old. Left to right, Burpee's Self Pruning Selection X, plant 1; Burpee's Self Pruning Selection No. 6, Plant 1; and Burpee's Self Pruning Selection No. 5, Plant 1.

PLATE 3

Healthy and infected leaves from stone tomato variety. The healthy leaf was obtained from the upper part of the plant while the infected leaf which is almost dried, was obtained from the lower part.

PLATE 4

Tomato leaves showing the symptoms of the leafmold disease.

FIG. 1. Lower surface of the leaf showing the small downy white patch of fungus growth.

2. Upper surface of the leaf showing the yellowish green tissues;

3. Lower surface of the leaves showing the light brown to dark velvety brown color due to heavy sporulation of the fungus. The tip of the leaflet is already dried due to the effect of the disease.

PLATE 5

Tomato leaves showing the advanced stages of the leafmold disease. The light brown and velvety dark brown areas on the lower surface of the leaves and drying of the leaves may be noted.

PLATE 6

Lower leaves affected with the leafmold disease.

FIG. 1. Upper surface of the leaf, showing the light green to yellowish green areas from which spores may also be produced. At X is a dark brown dead tissue involving nearly one-fifth of the leaf area.

FIG. 2. Upper surface of the leaflet showing numerous new lesions, with the characteristic whitish downy patch of fungus growth and the old sporulating areas which have dark velvety brown color.

PLATE 7

The tomato leafmold organism, *Cladosporium fulvum* Cke.

FIG. 1. Spores.

FIGS. 2, 3, 5, and 6 are germinating spores after 4, 8, 12, 24 hours, respectively.

FIG. 4. Conidiophores with some young undetached spores.

PLATE 8

Potted tomato plant artificially infected in the glasshouse by spraying spores of *C. fulvum* Cke. Photographed 25 days after inoculation.

PLATE 9

Burpee's Self Pruning Selections No. 1 to No. 6, growing in the glasshouse. Selection Nos. 1, 3, and 5, (left to right) are seen on the foreground while Selections Nos. 2, 4, and 6 not seen, are in the background just behind. In spite leafmold disease, these selections yielded very satisfactorily, while the unselected, susceptible strains yielded very poorly, and in certain instances failed to produce any fruit. Because of early *flowering* and *fruiting*, these plants have already matured and ripened fruits before the disease became serious. Planted, January 4, 1936 and photographed, April 15, 1936.

PLATE 10

Burpee's Self Pruning Selection No. 1. This plant produced 23 marketable size fruits weighing 1,798.5 grams. Planted January 4, 1936 and photographed April 15, 1936.

PLATE 11

Break O'Day Selections Nos. 1 and 2. These plants fruited also satisfactorily and yielded from 1,795.0 to 1,714.0 grams of fruits, respectively. Planted, January 4, 1936 and photographed, April 19, 1936.

PLATE 12

Golden Queen and Burpee's Matchless tomato varieties. These varieties are more susceptible and were more severely affected early in the season. These plants yielded very poorly as compared with either the Burpee's Self Pruning or with Break O'Day selections.

PLATE 1.

PLATE 2.

PLATE 3.

1 2 3

PLATE 4

PLATE 5.

1

2

PLATE 6.

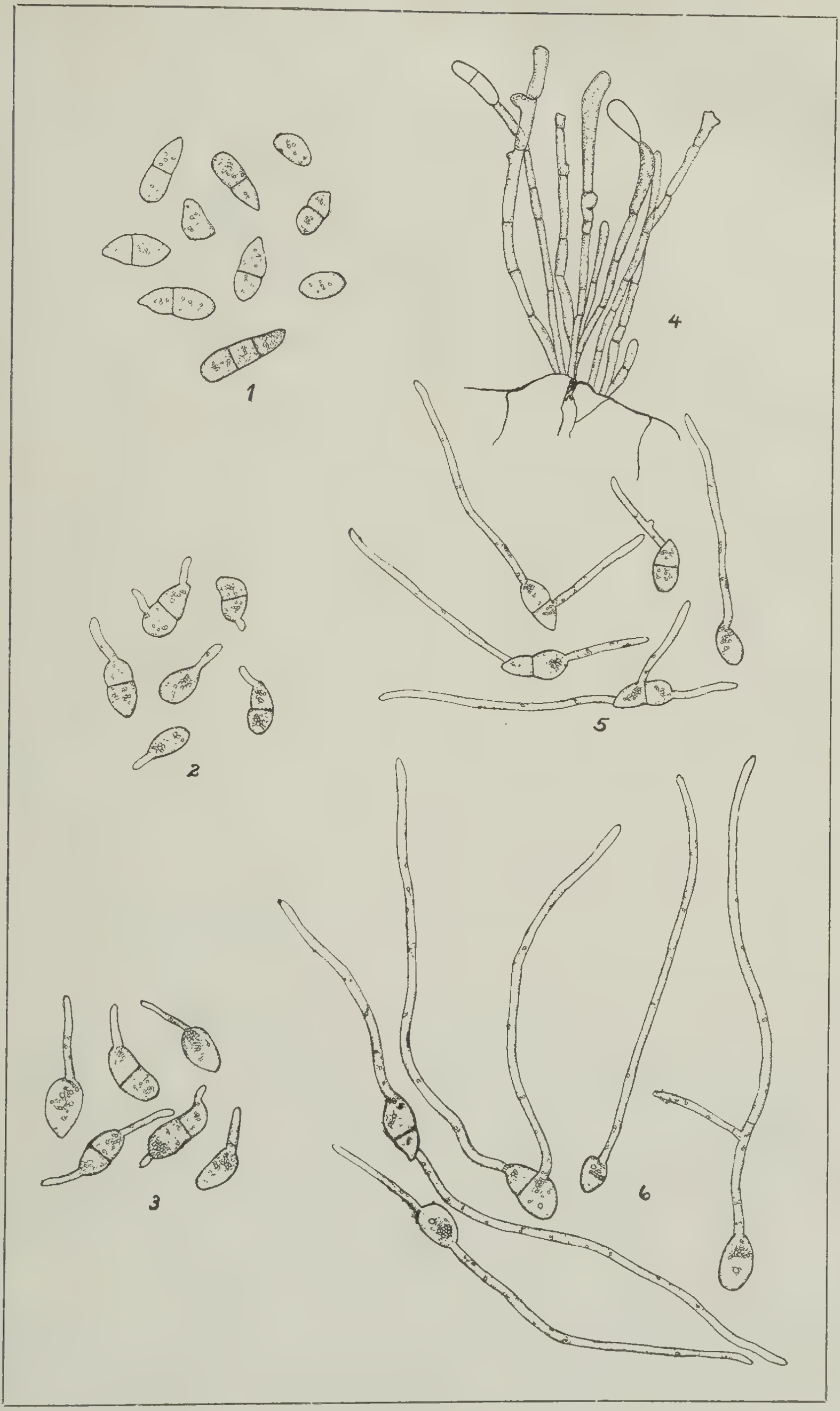


PLATE 7.

PLATE 8.

PLATE 9.

PLATE 10.

PLATE 11.

PLATE 12.

THE SETTING OF CARABAO MANGO FRUITS AS AFFECTED BY CERTAIN SPRAYS

By F. G. GALANG and FELIX D. LAZO

Of the Horticulture Section

TWO TEXT FIGURES

Mango flowers which have been overtaken by rain, shower, heavy dew or otherwise even only mere high atmospheric humidity during the fertilization period appeared to have met with varying degrees of failure to develop into fruits. There were instances where a total or 100 per cent losses occurred due to these unfavorable factors. Yet, it involves a considerable expense to make a mango tree flower because it has a despairing characteristic of erratic flowering. While it is true that the mango could be forced to become active as to make it flower or send out flushes by smudging, up to the present time, however, no means has as yet been found which would make the flowers develop into fruits with certainty. Mango fruits produced out of season fetch a better price in the market; therefore, it gives a handsome financial return to the mango growers. Considering this together with the cost of inducing the tree to flower, the importance of the question of how to influence the setting of the mango flowers into fruits, or to save them from ruin frequently resulting from showery weather, becomes obvious and interesting.

Some efforts were directed toward this end. Thus Clara(1) in 1927 claimed that "invariably the trouble is the falling off flowers, during showery weather" and that it is caused by a fungus organism known as *Glomerella cingulata* (Stonem.) Schrenk and Spaul. It is evident from this report that spores of the disease were already present in the trees and that the showery weather effected the optimum condition for the development of the disease. On the other hand, Palo and Garcia(3) in their studies on the control of leaf-hoppers and tip-borers on mango inflorescence, state that "anthracnose disease was suspected as one of the factors responsible for the blighting of the flowers because of favorable weather (for the disease) but

isolation studies for its causative agent did not reveal its presence." If this were the case, perhaps preventive precaution before the humid conditions of the air would help the mango growers. Torres(5) sprayed once with tap-water some mango flowers which have been fertilized three days or more. In other words he sprayed very newly set fruits and some continued to develop so he reported in 1931 "that the mean percentage of setting for the unsprayed group was 1.60 ± 0.26 per cent as compared with 2.80 ± 0.55 per cent for the sprayed lot, thus, showing an insignificant difference of 1.20 ± 0.60 per cent in favor of the spray treatment," and the same author concluded, "that a single spraying with water does not prove harmful to the young ovaries." In India, it was reported by Hartless(2) that rain, cloudy weather, excessive humidity, storm, drought, frost, cold, and insects during the flowering period of the mango constitute the most important and frequent causes of failure of the crop. On the other hand, Popenoe(4) wrote that "the scanty productiveness of many Indian mangoes had been attributed . . . to defective pollination." To the same author is also accredited the claim that the mango pollen "grains show a decided tendency to cling together especially in damp weather."

Wellington et al.(6) seemed to agree with all the others in their opinions when he and his coworkers enumerated "the main factors affecting fruit setting" as "meteorological, nutritional, sexual, and agencies affecting pollination." To find out, at least in part, the idiosyncrasy of the mango flower with respect to humid weather and certain sprays, this study was undertaken.

The direct objective of this study was to find out the effects of rain, tap-water, Black-leaf "40" plus soap, Fungi-bordo, lime-sulphur and calcium arsenate on the setting of the Carabao mango flowers into fruits. In this study, however, it was necessary to have some kind of an insight in the characteristics and behavior of the flowers in order to have a better light in understanding whatever the manifestation of the sprays.

The study was carried at the mango orchard of the Lamao Horticultural Station, Limay, Bataan, during the smudging season of 1933 to 1936. The 1933–34 season was mostly devoted to the study of the silent characteristics and behaviors of the mango flowers. Actual spraying was conducted during the last two seasons mentioned. No test was made during the regular flowering periods for lack of suitable materials. The trees did not flower perhaps as Hartless(2) claims due to ex-

haustion. The trees have already flowered when they were smudged.

MATERIALS AND METHODS

Studies on the Carabao mango flowers.—The plants which produced the flowers were grafted with selected scions. They were planted in 1923 in an orchard which has reddish clay loam soil. The plantation has a rather sloping topography, thus affording an excellent drainage.

When the buds became active as a result of smudging in December 1933 at least 50 buds were selected, labeled and numbered under each of the conditions, to wit, buds arising from terminal flushes and directly exposed or open to sunshine (terminal open), buds arising from terminal flushes but were shaded from the rays of the sun (terminal shaded), buds arising from lateral flushes and directly exposed to sunshine (lateral open), and buds arising from lateral flushes but were shaded (lateral shaded). When the buds were two to three days after they have shown external signs of activity, their daily elongation was taken individually until they ceased to elongate. The selected buds did not all develop into flower panicles as some of them were shoot buds. Others were attacked by tip-borers. Table 1 together with Chart 1 shows the average growth in length of 25 panicles each, of the four conditions mentioned above.

At what time of the day do most of the florets, or how many florets in a panicle open at a certain hour of the day was also a question of some importance. For this purpose, 15 panicles of normal growth and which had their first floret about to open were marked and closely observed. As soon as the florets in the panicles began to open, hourly observations from 6 a. m. to 6 p. m. were made. The number of perfect and imperfect (male) florets opening at every hour between 6 a. m. and 6 p. m. was determined separately in each of the 15 panicles marked. This observation continued until all the florets in the panicles under consideration have opened. To avoid possible confusion in the counting, the opened florets were pinched off with the aid of a pair of fine pointed forceps. Thus every floret found open during the succeeding observation must have done so during that particular hour. Only 10 of the 15 marked panicles successfully terminated the study. Some of them were accidentally broken in the course of the observation while two were destroyed by tip-borers. The results are presented in Table 2 and Chart 2.

The number of florets opening every day from the first until the last one in the panicle has opened, was likewise determined. It was desired to know how soon after the first floret has opened would most of them be ready to pollinate. The perfect and imperfect florets were separately recorded as shown in Table 3.

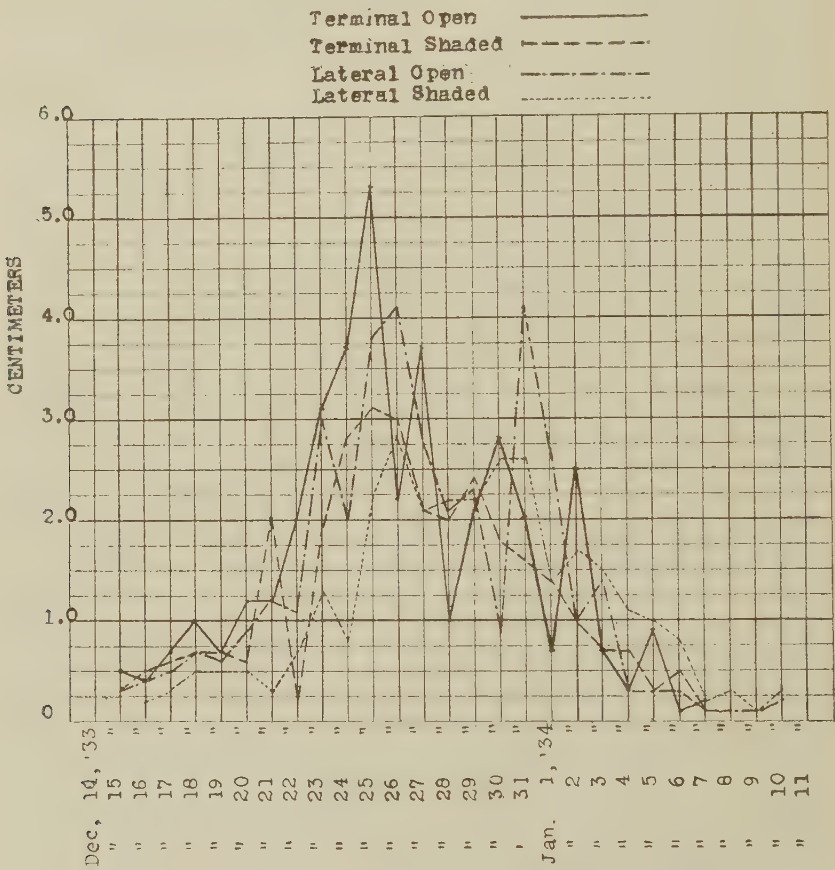


CHART 1. Average daily elongation of Carabao mango flower panicles.

The time it takes the anthers to open was studied with the aid of a watch and a hand lens. The moment the longitudinal suture of the anthers began to open and the time the opening was completed were recorded. Table 4 shows the results of the observation.

In the same manner as in determining the number of florets opening during certain hours of the day, the number of perfect and imperfect ones in the whole flower panicles were also studied. The point in view was to find out what per cent of the whole

panicle are staminate and what per cent are potential fruit forming florets. This will enable us to express approximately

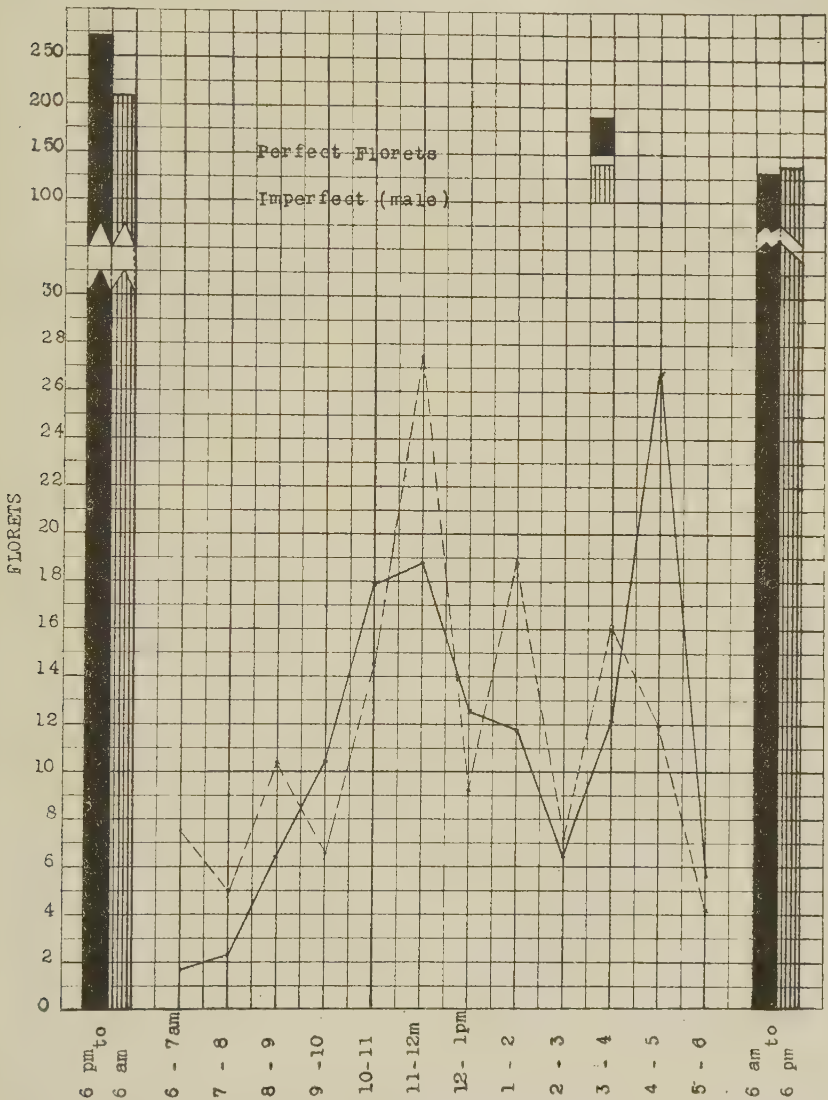


CHART. 2. Average number of florets opening in a Carabao mango flower panicle opening at different hours of the day

the fruit set in terms of per cent. Table 5 shows the summarized data on the number of florets per panicle of Carabao mango flower.

A closer external study of the florets and its behavior was undertaken. Figure 1 shows the oustanding external morphology of a typical Carabao mango perfect floret. The male floret is illustrated in Figure 2.

FIG. 1. A typical perfect floret of Carabao mango

FIG. 2. A typical male floret of Carabao mango

Spraying experiments.—Armed with the findings about the mango flower, an endeavor to find the effects of chemical sprays, rain and tap-water was attempted. During the smudging season of 1934–35 some of the grafted Carabao mango trees flowered very profusely. Three trees which had nearly the same quantity of flower panicles throughout the crown were selected. The trees had well developed and more or less spherical crowns with about 12 meters diameter. When the rachises were about 10 cm. long, each of the crowns was divided into seven divisions by means of tying a bamboo pole vertically against the main trunk, allowing the upper end of the pole to protrude about two and a half meters above the crowns. At the end of the pole were tied seven pieces of abacá twine ($\frac{1}{8}$ inch in diameter) with convenient length. The other ends of the abacá twines were in turn tied to pointed sticks which were driven to the ground so that they were fixed.

The number of panicles in each division was carefully taken and recorded. The kind of treatment or spray was labeled to the division that received it. In the morning of January 26, 1935, at about 8.30 a. m., actual spraying was performed. A section or a division was not sprayed with anything in order to serve as control.

Another division was sprayed with rain water which was collected and stored in demi-johns during the preceding rainy

season. The spraying was accomplished with the aid of a hand pump, the nozzle of which was so adjusted that the spray came out in a fine mist. The flowers including all the other parts of the tree in the section were thoroughly sprayed. The nozzle was directed to the higher parts of the tree with the use of a light pole.

Another section was sprayed with ordinary tap-water obtained from the faucet at the nursery of the Lamao Horticultural Station. The water was applied in the same manner as the rain water.

TABLE 1.—*Showing the average daily elongation in centimeters of twenty-five each of Carabao mango flower panicles*

Date	Terminal				Lateral			
	Open		Shaded		Open		Shaded	
	M	G	M	G	M	G	M	G
1933								
December 14	0.9	-------	0.7	-------	0.5	-------	0.5	-------
December 15	1.4	0.5	1.0	0.3	0.8	0.3	0.5	-------
December 16	1.8	0.4	1.5	0.5	1.2	0.4	0.7	0.2
December 17	2.5	0.7	2.1	0.6	1.7	0.5	1.0	0.3
December 18	3.5	1.0	2.8	0.7	2.4	0.7	1.5	0.5
December 19	4.2	0.7	3.5	0.7	3.0	0.6	2.0	0.5
December 20	5.4	1.2	4.1	0.6	3.9	0.9	2.5	0.5
December 21	6.6	1.2	6.1	2.0	5.1	1.2	2.8	0.3
December 22	8.6	2.0	6.3	0.2	6.2	1.1	3.5	0.7
December 23	11.7	3.1	8.2	1.9	9.2	3.0	4.8	1.3
December 24	15.4	3.7	11.0	2.8	11.2	2.0	5.6	0.8
December 25	20.7	5.3	14.1	3.1	15.0	3.8	7.8	2.2
December 26	22.9	2.2	17.1	3.0	19.1	4.1	10.6	2.8
December 27	26.6	3.7	19.2	2.1	21.9	2.8	12.7	2.1
December 28	27.6	1.0	21.2	2.0	24.0	2.1	14.9	2.2
December 29	29.7	2.1	23.6	2.4	26.3	2.3	17.1	2.2
December 30	32.5	2.8	25.4	1.8	27.2	0.9	19.7	2.6
December 31	34.5	2.0	27.0	1.6	31.3	4.1	22.3	2.6
1934								
January 1	35.2	0.7	28.4	1.4	34.0	2.7	23.7	1.4
January 2	37.7	2.5	29.4	1.0	35.0	1.0	25.4	1.7
January 3	38.4	0.7	30.1	0.7	36.4	1.4	26.9	1.5
January 4	38.7	0.3	30.8	0.7	36.7	0.3	28.0	1.1
January 5	39.6	0.9	31.1	0.3	37.0	0.3	29.0	1.0
January 6	39.7	0.1	31.6	0.5	37.3	0.3	29.8	0.8
January 7	39.9	0.2	31.7	0.1	37.4	0.1	30.0	0.2
January 8	39.9	-------	31.8	0.1	37.5	0.1	30.3	0.3
January 9	-------	-------	31.8	-------	37.6	0.1	30.4	0.1
January 10	-------	-------	-------	-------	37.8	0.2	30.7	0.3
January 11	-------	-------	-------	-------	37.8	-------	30.7	-------
Total	39.0		31.1		37.3		30.2	
Average	1.63		1.24		1.38		1.12	

M—Stands for measurement.
G—Stands for growth.

TABLE 2.—*Showing the number of florets opening at different hours of the day*

Time	Panicle number											
	1		2		3		4		5		6	
	P	I	P	I	P	I	P	I	P	I	P	I
6 p. m.–6 a. m.	365	207	257	213	140	140	246	178	350	314	367	209
6 a. m.–7 a. m.	----	----	2	4	----	----	1	3	4	28	----	----
7 a. m.–8 a. m.	3	1	----	----	----	4	1	11	3	1	1	----
8 a. m.–9 a. m.	19	20	4	13	----	3	3	8	----	----	21	24
9 a. m.–10 a. m.	28	12	1	----	----	----	2	8	14	3	30	16
10 a. m.–11 a. m.	32	20	10	24	8	6	17	6	17	12	33	21
11 a. m.–12 noon	17	4	22	24	5	13	11	24	32	63	17	5
12 noon–1 p. m.	21	25	10	2	6	6	10	6	12	3	23	27
1 p. m.–2 p. m.	10	27	16	27	----	11	5	14	28	15	12	29
2 p. m.–3 p. m.	13	10	2	5	4	----	1	19	11	----	13	11
3 p. m.–4 p. m.	18	19	7	9	1	5	16	11	15	33	17	18
4 p. m.–5 p. m.	19	9	54	14	24	2	12	19	21	13	21	11
5 p. m.–6 p. m.	14	5	4	3	4	3	2	1	2	7	12	3
6 a. m.–6 p. m.	194	152	132	125	52	53	81	130	159	178	200	155

Time	Panicle number								Total		Average	
	7		8		9		10					
	P	I	P	I	P	I	P	I	P	I	P	I
6 p. m. 6 a. m.	136	130	351	299	260	217	256	189	2,728	2,096	272.8	209.6
6 a. m.–7 a. m.	--------	--------	3	30	5	7	2	3	17	75	1.7	7.5
7 a. m.–8 a. m.	--------	6	3	2	1	3	11	21	23	49	2.3	4.9
8 a. m.–9 a. m.	2	5	--------	3	7	15	8	13	64	104	6.4	10.4
9 a. m.–10 a. m.	--------	1	15	7	2	1	12	18	104	66	10.4	6.6
10 a. m.–11 a. m.	9	6	19	12	12	27	22	11	179	145	17.9	14.5
11 a. m.–12 noon	7	15	32	71	25	27	16	29	184	275	18.4	27.5
12 noon–1 p. m.	8	7	13	6	12	5	10	5	125	92	12.5	9.2
1 p. m.–2 p. m.	2	11	25	13	16	28	4	13	118	188	11.8	18.8
2 p. m.–3 p. m.	6	--------	12	3	3	6	--------	18	65	72	6.5	7.2
3 p. m.–4 p. m.	3	8	18	35	9	11	17	12	121	161	12.1	16.1
4 p. m.–5 p. m.	23	4	25	13	59	17	10	17	268	119	26.8	11.9
5 p. m.–6 p. m.	6	4	4	9	3	2	5	4	56	41	5.6	4.1
6 a. m.–6 p. m.	66	67	169	204	154	149	117	164	1,324	1,387	132.4	138.7

NOTE.—P stands for perfect florets. I stands for imperfect florets.

The fourth division was sprayed with calcium arsenate at the concentration of nine level spoonfuls for every petroleum canful of tap-water. The spray was continually stirred while it was being applied.

It was noticed two days after the operation that the rachises of the flowers showed signs of burning. The concentration was, therefore, reduced to five level spoonfuls for every petroleum canful of water in the succeeding tests and applications.

Dry lime sulphur at the dilution of seven level spoonfuls for every five gallons of water was sprayed thoroughly to one division. The spray was stirred continuously while it was being applied in a fine mist.

Another section was carefully sprayed with soap solution which was prepared by dissolving 40 grams of chip soap (from the Bureau's stock) in a petroleum canful of water. To this solution was added four teaspoonfuls of Black Leaf "40" (nicotine sulphate). The spray was applied in fine mists with the aid of a well adjusted nozzle.

The last division was treated with Fungi-bordo. The spray was prepared by disolving ten level spoonfuls of the Fungi-Bordo powder to a five gallons of water. It was vigorously stirred before the application and the stirring continued during the spraying.

Each of the selected experimental trees was sprayed in the same manner as described.

The whole spraying operation was repeated after every four days until all the experimental flowers had passed the fertilization period. Care was exercised that the sections or divisions always received the same spray as they got in the first application.

During the course of the study, enormous number of mango leaf-hoppers attacked the newly fertilized flowers. With the view of minimizing the damages of the insects, which may cause the entire failure of the crop at the station, the soap solution plus nicotine sulphate spray was applied thoroughly to all parts of the experimental trees, including the control sections, every other day. Some nearby trees were also sprayed. The spray against the hoppers was continued regularly until the fruits were about the size of a pea seed. Spraying was only occasional after then. Aside from the factors or variables under consideration, all the sections were treated as uniformly as possible.

When most of the fruits were about an inch long, they were carefully counted and recorded separately with the use of a hand tally-counter, for each section. The results are presented in Table 6.

Because of the interference of the mango leaf-hoppers and the desire to verify the data, the experiment was repeated during the 1935–36 smudging season. This time the trees did not flower so heavily as in the previous season. The flowers were produced in patches in the crowns. For this reason, the crowns were not divided in the same number as the previous experimental trees but were only divided into halves. One half was control and the other was treated with a variable. Five trees were selected. Because of the deleterious effect on the flowers of the calcium arsenate at the concentration tried, as observed in the first three tests (Table 6), this spray was not included in the trial in 1935–36.

The mango leaf-hoppers did not cause much trouble during the progress of this study.

Spraying was done much earlier than the experiments conducted during the 1934–35 seasons. When the buds showed signs of activity as a result of smudging, the divisions were sprayed at once with the treatment intended for each of them. The treatment was carried at weekly intervals until the flowers began to open, at which time the procedure followed during the previous season was precisely adopted. The number of panicles under treatment or division was taken when the inflorescences were most conspicuous, i. e., when most of the florets were in their fertilization period. The number of fruits was recorded when most of them were about one inch long. Table 6a shows the results obtained from the 1935–36 trial.

DISCUSSION OF RESULTS

Carabao mango flowers.—A study of Table 1 together with Chart 1 shows that the panicles exposed to sunshine had greater growth than those which were shaded. This was true on inflorescences born both by the terminal and lateral twigs. The average daily elongation of the terminal inflorescences was 1.63 and 1.24 cm. for those exposed to the sunshine and shaded from the direct sun rays, respectively. The lateral flower panicles in the open made an average daily growth of 1.38 cm. in length and 1.12 cm. for the shaded ones (Table 1).

In general the rate of elongation of the Carabao mango inflorescence was rather slow at the beginning, but it gradually increased up to about the fifteenth day of their growth when 5.3, 3.1, 4.1, and 2.8 cm. was attained by the terminal open, terminal shaded, lateral open, and lateral shaded inflorescences, respectively, as may be seen in Chart 1. In fact it may be of interest to mention that this behavior of the mango buds is one of the criteria of mango smudgers in distinguishing flowers from shoots when the growth is only a few millimeters long. Generally the leaf-buds grow much faster than the flower buds. After about fifteen days, the growth decreased gradually until it finally ceased when the floret at the tip had fully developed, which was after about another fifteen days more.

The differences in the daily elongation of the panicles in the different conditions were small, but considering that they grew for 28 to 31 days the difference may reach up to 7.80 to 10.92 cm. which means a lot of florets in favor of the flower panicles exposed to direct sunshine. The difference was of course obviously accountable to the greater photosynthetic activity in those parts of the plants.

It was observed that more florets opened at night than at day time. From 6 p. m. to 6 a. m. 272.8 perfect and 209.6 imperfect (male) florets opened while 132.4 perfect and 138.7 male florets opened from 6 a. m. to 6 p. m. (Table 2 and Chart 2). From 6 a. m. to 7 a. m., an average of 1.7 perfect florets per panicle had opened. The number of florets that opened during each succeeding hour increased rapidly up to 18.4 florets at 11 a. m. to 12 noon, diminished down to 6.5 florets at 2 to 3 p. m. and soaring again sharply reaching the maximum of 26.8 opened florets at 4 to 5 p. m. From that time the number abruptly dropped to 5.6 at the next hour (Table 2).

The trend of opening of the male florets followed closely the curve of the perfect florets with the difference that the maximum male florets opened at 11 a. m. to 12 noon while that of the perfect was at 4 to 5 p. m. (Chart 2).

Table 3 shows that all the florets in a Carabao mango panicle opened after 12 to 18 days or an average of 15.16 $\pm$ 0.20 days from the time the first floret in the panicle opened. Most of the perfect florets in the panicle (more than 76 per cent) opened from the third to the eighth day. From the first to the eighth day, many more perfect florets opened than male florets. However, from the ninth to the last day more male than

TABLE 3.—*Showing the number of florets opening daily in a Carabao mango flower panicle*

Panicle number	Number of florets opening on the— 1st day		2nd day		3rd day		4th day		5th day		6th day	
	P	I	P	I	P	I	P	I	P	I	P	I
1	3		11		38	3	110	7	137	29	146	58
2	4		20		45	2	94	7	77	18	71	36
3	2		10	2	22	1	51	7	39	7	31	18
4	11		23	2	56	3	60	16	78	25	33	52
5	14		44	7	83	13	115	19	98	64	81	112
6	2	1			40	15	67	35	103	65	111	51
7	9		57	2	66	3	93	6	135	35	170	36
8	4		7		37	1	36	4	64	9	96	35
9	26	2	62	11	57	14	104	13	105	80	110	63
10	20	3	49	7	54	7	76	17	108	12	90	37
11	5	1	43	6	47	8	101	12	115	15	122	26
12	2		31	5	54	2	60	10	118	7	87	10
13	7		23		61	3	70	4	127	34	77	33
14	7		31	2	41	2	56	3	70	15	108	35
15	7	1	45	4	70	3	72	8	120	21	143	31
16	3		43		74	7	133	11	73	2	204	45
17	4		17	2	45	2	140	17	130	45	100	20
18	11	1	57	8	145	49	193	23	66	20	86	40
19	5	7	18	6	95	14	81	16	12	10	81	25
20	5		24	6	64	10	91	18	119	80	125	50
21	3		22	2	40	6	24	8	50	34	15	7
22	6	5	24	29	36	4	20	8	12	15	19	18
23	8		17	4	77	10	110	18	100	39	98	36
24	4		24	5	65	4	33	24	39	46	125	85
25	9		90	12	145	47	322	352	224	99	182	112
Total	181	21	792	122	1,557	233	2,312	663	2,369	826	2,511	1,071
Average	7.24	0.84	31.68	4.88	62.28	9.32	92.48	26.52	94.76	33.04	100.44	42.84

TABLE 3.—*Showing the number of florets, etc.*—Continued.

Panicle number	Number of florets opening on the—											
	7th day		8th day		9th day		10th day		11th day		12th day	
	P	I	P	I	P	I	P	I	P	I	P	I
1	68	113	25	59	16	55	5	24	-------	6	-------	5
2	32	64	23	43	7	64	7	55	3	26	2	16
3	24	35	7	25	2	47	1	24	3	14	-------	10
4	32	37	32	64	4	54	7	30	5	15	2	2
5	27	118	12	77	4	44	2	30	-------	8	1	1
6	130	102	100	150	66	180	44	81	49	111	78	38
7	119	71	81	88	34	58	15	44	13	23	4	28
8	119	30	100	54	106	68	52	48	46	60	23	30
9	50	79	45	60	12	18	7	21	6	14	1	3
10	43	17	24	26	7	4	7	8	5	12	5	6
11	71	58	103	84	29	75	46	58	38	32	29	29
12	73	96	44	55	52	78	15	25	21	24	11	12
13	150	91	63	74	22	112	50	42	31	29	21	35
14	90	96	65	58	77	67	51	26	33	44	14	18
15	85	66	136	105	54	54	47	61	48	49	21	25
16	101	51	88	62	43	63	34	36	12	19	12	4
17	67	50	42	36	30	35	56	15	5	40	45	25
18	25	41	25	36	15	27	12	30	18	4	25	5
19	64	48	50	17	37	12	16	20	8	3	5	3
20	165	58	110	42	130	89	70	85	70	91	48	57
21	18	2	5	8	5	2	5	2	15	38	10	31
22	30	25	24	3	40	8	18	3	30	20	5	9
23	200	81	182	34	48	18	2	34	35	82	12	64
24	7	115	26	15	2	5	3	20	2	15	-------	5
25	124	36	79	60	68	63	36	28	28	13	39	7
Total	1,914	1,580	1,491	1,335	960	1,299	608	850	524	792	413	468
Average	76.56	63.20	59.64	53.40	38.40	51.96	24.32	34.00	20.96	31.68	16.52	18.72

Panicle number	Number of florets opening on the—												Number of days
	13th day		14th day		15th day		16th day		17th day		18th day		
	P	I	P	I	P	I	P	I	P	I	P	I	
1													12
2	1	5	4										14
3		2						1					16
4	2	4											13
5		1		1									14
6	9	30	5	15	5	4	4	1	1	1			17
7		10	1	3									14
8	10	8	6	9	2	3	2				1		18
9	1	3		1									14
10	5	1	1	1				1					16
11	22	23	13	7	6	4	1		1				17
12	5	9	5	2	3	1			1				17
13	3	11	1	14	2	1	1	1					16
14	18	15	8	15	7	3	2	1		2			17
15	18	17	10	8	1	6							15
16	12	4	4	3	3	2							15
17	2	1	7	38									14
18	20			1		5							15
19	4	12	5	5		5							15
20	30	23	2	6		2							15
21	3	5	1	1		1							15
22	10	18	4	25	1	4		1					16
23	10	35	3	7									14
24	1	1		1	1	1							15
25	4	15	2	1	1	2							15
Total	190	253	82	164	32	44	10	6	3	3	1		379
Average	7.60	10.12	3.28	6.56	1.28	1.76	0.40	0.24	0.12	0.12	0.04		15.16 ± .20

TABLE 4.—*Showing the length of time it takes the anthers of Carabao mango florets to open*

Date	Floret No.	Time the anthers— Begin to open	Time the anthers— Fully open	Time the anthers open
1934				*min.*
January 6	1	7.25 a. m.	7.34 a. m.	9.0
January 6	2	8.005 a. m.	8.09 a. m.	8.5
January 6	3	8.105 a. m.	8.19 a. m.	8.5
January 6	4	8.005 a. m.	8.10 a. m.	9.5
January 6	5	8.23 a. m.	8.31 a. m.	8.0
January 6	6	8.31 a. m.	8.39 a. m.	8.0
January 6	7	8.35 a. m.	8.44 a. m.	9.0
January 6	8	8.42 a. m.	8.51 a. m.	9.0
January 6	9	8.45 a. m.	8.54 a. m.	9.0
January 6	10	9.11 a. m.	9.20 a. m.	9.0
January 6	11	9.28 a. m.	9.365 a. m.	8.5
January 6	12	10.48 a. m.	10.56 a. m.	8.0
January 6	13	11.05 a. m.	11.13 a. m.	8.0
January 6	14	11.27 a. m.	11.35 a. m.	8.0
January 6	15	11.39 a. m.	11.47 a. m.	8.0
January 6	16	12.51 p. m.	12.575 p. m.	6.5
January 6	17	12.55 p. m.	1.03 p. m.	8.0
January 7	18	7.35 a. m.	7.44 a. m.	9.0
January 7	19	7.42 a. m.	7.51 a. m.	9.0
January 7	20	8.28 a. m.	8.375 a. m.	9.5
January 7	21	9.11 a. m.	9.19 a. m.	8.0
January 7	22	9.30 a. m.	9.39 a. m.	9.0
January 7	23	9.50 a. m.	9.59 a. m.	9.0
January 7	24	10.15 a. m.	10.25 a. m.	10.0
January 7	25	10.40 a. m.	10.48 a. m.	8.0
January 7	26	11.10 a. m.	11.19 a. m.	9.0
January 7	27	11.46 a. m.	11.54 a. m.	8.0
January 7	28	12.45 p. m.	12.51 p. m.	6.0
January 7	29	12.58 p. m.	1.055 p. m.	7.5
January 8	30	7.03 a. m.	7.11 a. m.	8.0
January 8	31	7.28 a. m.	7.39 a. m.	11.0
January 8	32	7.45 a. m.	7.54 a. m.	9.0
January 8	33	8.30 a. m.	8.39 a. m.	9.0
January 8	34	9.43 a. m.	9.525 a. m.	9.5
January 8	35	9.57 a. m.	10.06 a. m.	9.0
January 8	36	10.25 a. m.	10.32 a. m.	7.0
January 8	37	11.40 a. m.	11.48 a. m.	8.0
January 8	38	12.18 p. m.	12.265 p. m.	8.5
January 9	39	9.15 a. m.	9.24 a. m.	9.0
January 9	40	9.40 a. m.	9.48 a. m.	8.0
January 9	41	10.30 a. m.	10.38 a. m.	8.0
January 9	42	11.15 a. m.	11.23 a. m.	8.0
January 9	43	12.05 p. m.	12.125 p. m.	7.5
January 9	44	12.09 p. m.	12.16 p. m.	7.0
January 10	45	8.05 a. m.	8.14 a. m.	9.0
January 10	46	9.25 a. m.	9.35 a. m.	10.0
January 10	47	10.12 a. m.	10.20 a. m.	8.0
January 10	48	11.50 a. m.	11.56 a. m.	6.0
January 10	49	12.01 p. m.	12.08 p. m.	7.0
Total	49			411.0
Average	1			8.39
P. E. of Mean				±0.09

perfect florets had opened (Chart 3). The fact that most of the perfect florets are located at the middle of the tips of the rachises perhaps this explains why most of them opened somewhat earlier than most of the male florets and also confirms the observation that the fruits of Carabao mango were born mostly at points from the middle to the tip of the rachises. Considering all other factors equal it may be stated in passing that with the greater number of male flowers more pollen-grains are produced and consequently a greater chance of pollination because of the greater proportion of male to female florets.

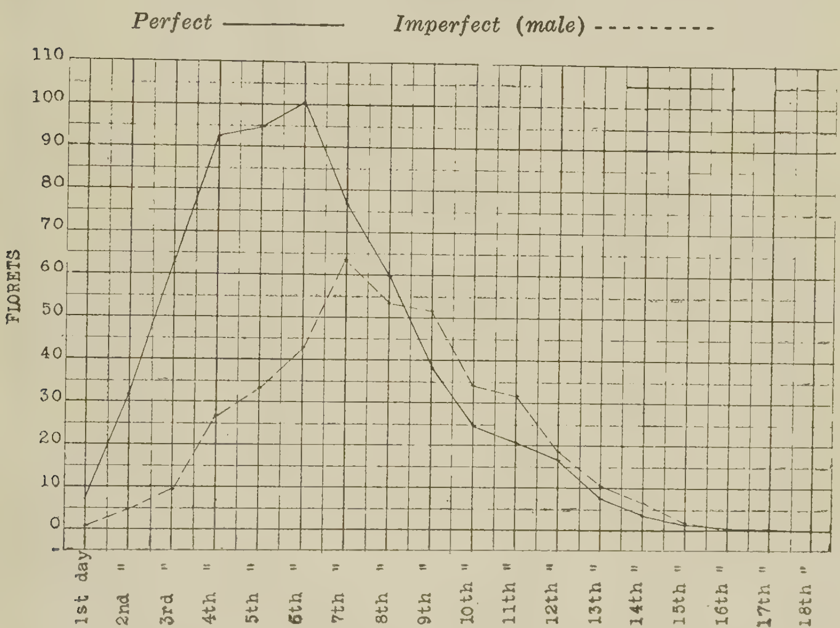


CHART 3. Trend of opening of perfect and imperfect florets

While dealing in the question of pollination, the nature of dehiscence was considered and it was observed that the Carabao mango anthers did not dehisced in a snap as in some plants but on the contrary, rather slowly. From the moment the suture began to open which was readily observed with the aid of a hand lens, until the time the lids of the anther had completely turned inside out it took 8.39 ± 0.09 minutes (Table 4). At first the opening of the suture was very slow until more or less two-thirds of the length had separated and turned inside out at a comparatively faster rate and then continued on the process slowly. A completely dehisced anther suggested the shape of a very tiny kidney with ashen-gray color. A Carabao

mango anther was pinkish light violet becoming slightly darker or violet red as it was about ready to dehisce.

Table 5 shows that a Carabao mango flower panicle, depending upon the size, had from 363 to as high as 2,200 or an average of 1,009.63 ± 54.01 individual florets. Of this figure, 216 to 1,353 with 631.07 ± 33.51 average or 62.51 per cent were perfect. From this it could be readily seen that even only one per cent would develop into fruits and allowing further one-half of the set for natural fall and the destructive agencies there would still be an excellent crop because in such a case more than three fruits would yet mature in each panicle.

TABLE 5.—*Showing the number of florets in a Carabao mango flower panicle*

Panicle No.	Number of—		Total number of florets in the flower panicle
	Perfect florets	Imperfect florets	
1	1,353	847	2,200
2	588	282	870
3	690	326	1,016
4	698	290	988
5	481	203	684
6	1,053	617	1,670
7	420	356	776
8	220	213	433
9	378	314	692
10	507	541	1,048
11	839	315	1,154
12	216	147	363
13	279	195	474
14	390	103	493
15	847	466	1,313
16	396	342	738
17	804	879	1,683
18	787	407	1,194
19	711	359	1,070
20	586	382	968
21	494	162	656
22	793	435	1,228
23	582	336	918
24	809	484	1,293
25	682	402	1,084
26	877	459	1,336
27	559	359	918
Maximum	1,353	879	2,200
Minimum	216	103	363
Total	17,039	10,221	27,260
Average	631.07	378.55	1,009.63
P. E. mean	±33.51	±23.96	±54.01
Percentage	62.51	37.49	100.00

The male florets of Carabao mango flower were observed to be 37.49 per cent, ranging from 103 to 879 per panicle of flowers.

Figure 1 shows an enlarged drawing of a perfect floret. As described by Popenoe(3) it is subsessile. It has five ovate-lanceolate concave sepals which are covered with fine pubescence. The short pedicel together with the calyx is pale green.

The corolla is composed of five ovate-lanceolate petals which are white at the margin and turning yellow toward the central base. The corolla is inserted at the base of a fleshy and vaguely lobed slightly flattened globose disk. On the disk is obliquely placed spherical pale yellow ovary which is provided with a very slightly tapering about three milimeters long style, ending at an almost needle-point-like stigma. At the side opposite the inclination of the style is a violet red anther borne by a slender filament. Although the usual number of stamens is five, only one or two stamens develop properly to bear pollen-grains. The rest are only staminodes.

The male floret is in all cases similar to the perfect floret with the exception of the absence of the pistil in the male floret. The anthers are then borne at the center of the disk (Fig. 2).

The characteristics of the Carabao mango flower show that they are insect-pollinated. The almost needle-point-like stigma, the relative positions of the anther and stigma, the mode of dehiscence of the anthers, and the cohesive tendency of the pollen-grains indicate that it is entomophilous.

Spraying experiments.—Table 6 shows the results of the spraying experiments conducted during the 1934–35 smudging season. As already stated elsewhere in this paper, the mango hoppers were extraordinarily abundant during the season and great damage was suffered by the crops. Most of the flowers were ruined by the insects, so that the percentages of setting were very much below normal, in spite of the fact that the sets obtained were beyond expectation, considering the abundance of the pests and the total ruin of the flowers in the neighboring trees which were not sprayed. The spray against the insects was always applied in the afternoon because it was observed that very negligible number of anthers dehisced in the late afternoon. The spray therefore unless it was too concentrated to adversely affect the flowers, did not interfere very much in the pollinating activities of the beneficial insects. However, it was noticed that there were again hoppers in the sprayed trees the following morning. Most of them must have come from the unsprayed trees while the rest might have escaped from the effect of the spray.

It appeared that the calcium arsenate with the concentration used was rather strong for the flowers. Signs of burning were observed soon after the first spraying so that in the succeeding application the concentration was lowered. Even at this the percentages of setting was so low that of the 740,875 perfect florets treated with calcium arsenate only six fruits or 0.00082 per cent set was obtained. One-half per cent lead arsenate spray was also observed by Palo and Garcia(2) to be toxic on the open flowers.

In the case of the Black Leaf "40" plus soap, 478,981 perfect florets contained in 759 panicles were sprayed. Of this number, 109 fruits set, which was 0.05478 per cent was obtained. This was second highest percentage of setting secured during the season. This was also true in the test carried during the 1935–36 smudging season, 0.19416 per cent having been obtained (Table

TABLE 6.—*Showing the effects of certain sprays, rain and tap-water on the fruit setting of Carabao mango flowers. (1934–1935 season.)*

Test number	Treatment	Number of panicles treated	Estimated number of perfect florets treated [a]	Number of fruits set	Percentage of fruits set	Average percentage of setting
1	Calcium arsenate	502	316,797	2	0.00063	
2	Calcium arsenate	328	206,990	0	0.00000	0.00082
3	Calcium arsenate	344	217,088	4	0.00184	
1	Black leaf "40"	257	162,184	52	0.03206	
2	Black leaf "40"	442	278,933	8	0.00287	0.05478
3	Black leaf "40"	60	37,864	49	0.12941	
1	Fungi-bordo	427	269,467	17	0.00631	
2	Fungi-bordo	198	124,952	6	0.00480	0.00947
3	Fungi-bordo	110	69,418	12	0.01729	
1	Lime sulphur	273	172,282	53	0.03076	
2	Lime sulphur	464	292,816	0	0.00000	0.06389
3	Lime sulphur	65	41,020	66	0.16090	
1	Rain water	558	352,137	63	0.01789	
2	Rain water	478	301,651	21	0.00696	0.02023
3	Rain water	115	72,573	26	0.03583	
1	Tap-water	403	254,321	5	0.00197	
2	Tap-water	398	251,166	3	0.00119	0.00469
3	Tap-water	901	568,594	62	0.01090	
1	Control	496	213,011	32	0.01502	
2	Control	350	220,874	27	0.01222	0.02745
3	Control	115	72,573	40	0.05512	

[a] Estimate was based on 631.07 perfect florets for each panicle as per Table 5.

6a). The spray helped in minimizing the injury of the leaf-hoppers although they were not seriously dangerous in number in the latter season.

The sections treated with Fungi-bordo had 735 flower panicles with 463,837 perfect florets. Only 35 fruits were realized, thus giving an average of 0.00947 per cent setting. This treatment although it gave proportionately more fruits than what was obtained in the calcium arsenate treated sections, was lower than the average setting of the untreated sections. The same sort of results were obtained in the experiment carried in the 1935–36 season.

Lime sulphur gave the best results of this spraying study. Of the 802 panicles having 506,118 perfect florets, 119 fruits set, giving an average of 0.06389 per cent setting, in spite of the fact that in the second test for this treatment no fruit was obtained. It may be mentioned that the second test during the season was started rather late so that the hoppers had already done considerable damage. In the study carried in 1935–36 season, a difference of 0.07296 per cent over the control was obtained and this treatment was also the best among those tried during the season.

The sections sprayed with rain water had 1,151 panicles with perfect florets estimated to be 726,361. The average setting was 0.02023 which was 0.00722 per cent less than that of the control. However, this was very much higher than the setting

TABLE 6a.—*Showing the effects of certain sprays, rain and tap-water on the fruit setting of Carabao mango flowers. (1935–1936 season.)*

Treatment	Number of panicles treated	Estimated number of perfect florets treated [a]	Number of fruits set	Percentage of fruits set	Difference
Black leaf "40"	182	114,855	223	0.19416	+0.01861
Control	269	169,758	298	0.17555	
Fungi-bordo	81	51,117	61	0.11933	—0.08415
Control	88	55,534	113	0.20348	
Lime sulphur	92	58,058	91	0.15674	+0.07296
Control	87	54,903	46	0.08378	
Rain water	118	74,466	99	0.13295	—0.04259
Control	269	169,758	298	0.17554	
Tap-water	233	147,039	168	0.11423	—0.03330
Control	319	201,311	297	0.14753	

[a] Estimate was based on 631.07 perfect florets for each panicle as per Table 5.

obtained in the calcium arsenate treatment. In the study carried out in the following smudging season, similar trend of

results were realized. This simply showed that the rain water itself was not the direct cause of the total failures of the mango blossom to set fruits. Rather it was due to lack of pollination which of course, rain was an important adverse factor. As stated by Palo and Garcia, "rain . . . impaired the activity of the pollinating insects so much that many of the flowers remained unfertilized." Popenoe believes that the mango pollen-grains have the tendency to cling together especially during damp weathers. Considering that the mango flowers' characteristics were observed to be more entomophilous rather than anemophilous, rain therefore was an important hindrance in the pollination of the mango flowers. Also it has been reported that rains and showery weathers render the development of the anthracnose disease to the optimum. Rain, therefore, should be regarded with serious concern in the setting of mango fruits in that it is a strong limiting factor in pollination, for it favors the attacks of anthracnose disease, aside from the physical injury which obviously strong and heavy rain imparts to the comparatively tiny and tender mango florets.

These results of observations more or less give an idea of the nature and cause of the indirect unfavorable effects of rains and showery weather. The problem, therefore, is how to counteract these effects. To control the weather condition is a difficult proposition. However, it is fortunate that the mango is amenable to smudging. This therefore could be taken advantage of by smudging the trees so that the pollinating period of the flowers should coincide with the dry weathers. Another way to go around the effect of bad weather is the breeding of certain varieties or strains whose flowers could set and develop fruits despite rain and humid conditions of the atmosphere. It is of interest to mention that some Indian mangos and the Huani (*Mangifera odorata* Grif.) have been observed to set fruits freely at Lamao, Bataan, even without smudging and in spite of rain or showery weather during their blooming periods.

Tap-water treatment gave an average of 0.00469 per cent from 1,074,081 perfect florets in 1,702 panicles. This was lower than the results obtained from the rain water treatment (Table 6). It was believed that the very limited ammonia from the air in the rain was undesirable with the flowers, but it was found from this study that the different organisms likely to be present in the tap-water perhaps made it worse than the rain to the flowers.

The effects of tap-water on the flowers may be said to be similar to that of the rain. But should spraying be necessary for the control of insect pests and diseases, it is suggested that it should be applied in the afternoon because it was observed that the greatest majority of the anthers dehisced in the morning. Very negligible number shed their pollens in the late afternoon. The anthers would have dried in the following morning when they dehisce, thus the activities of the pollinating insects would be least impaired.

SUMMARY

1. This paper presents the results of some studies at Lamao, Bataan, on the Carabao mango flower and the effect of certain sprays, rain water and tap-water on the setting of fruits.

2. The average daily elongation of the terminal inflorescences was 1.63 and 1.24 cm. for those exposed to the sunshine and shaded from the direct sun rays, respectively.

3. The lateral flower panicles had 1.38 cm. daily growth in length for those open to the sun rays and 1.12 cm. for the shaded inflorescences.

4. The panicles exposed to the direct sunshine were 7.80 to 10.92 cm. longer than those which were shaded.

5. More florets opened between 6 p. m. to 6 a. m. than from 6 a. m. to 6 p. m. During the night, 272.8 perfect and 209.6 male florets opened while 132.4 perfect and 133.7 male florets opened during the day, or 23.01 and 19.54 per cent, respectively.

6. The greatest number of perfect florets (26.8) opened at 4 to 5 p. m. while in the case of the male florets the most number opened at 11 a. m. to 12 noon.

7. All the florets in a Carabao mango flower panicle opened from 12 to 18 days or an average of 15.16 ± 0.20 days from the time the first floret in the inflorescence opened; more than 76 per cent opening from the third to the eighth day.

8. The greatest number of the perfect florets open in the first 3 to 8 days while more of the male open in the later days.

9. The Carabao mango anthers did not open in a snap but very slowly, the whole operation taking place in 8.39 ± 0.09 minutes.

10. Depending upon the size of the panicle, each Carabao mango inflorescence had 363 to 2,200 florets, or an average of $1{,}009.63 \pm 54.01$ individual flowers.

11. There were 62.51 per cent perfect florets in a Carabao mango inflorescence.

12. The Carabao mango is polygamous and the characteristics indicated it to be entomophilous.

13. Calcium arsenate at the concentration of five to nine level spoonfuls for every petroleum canful of water had burning effect upon the open florets.

14. Four teaspoonfuls of Black Leaf "40" added to five gallons of soap solution prepared by disolving 40 grams of chip soap in a petroleum canful of water, gave the second highest percentage of setting among the sprays studied. The average setting obtained with this treatment was 0.05478 per cent for 1934–35 smudging season and 0.19416 per cent for 1935–36 season.

15. The section treated with Fungi-bordo gave 0.00947 per cent setting in the first season and 0.11933 per cent in the second. These were lower than the percentage setting of the control.

16. Lime-sulphur at the concentration of seven spoonfuls for every five gallons of water gave the highest percentage of setting in this observation. In both the 1934-35 and 1935-36 season trials, the treated sections gave 0.03644 and 0.07296 per cent higher than the control, respectively.

17. The sections treated with rain water and tap-water had fruit setting percentages lower than the control. Rain water and ordinary tap-water adversely affected pollination, more so with the latter treatment, but they were not observed to directly effect wholesale blighting of the flowers.

18. Spray of any sort was found detrimental to a certain degree to the setting of mango.

LITERATURE CITED

1. CLARA, FELICIANO M. The anthracnose of mango in the Philippines. The Phil. Agric. Rev. 20 (1927): 271–273.
2. HARTLESS, A. C. Mango crops and some factors influencing them. Agric. Journ. India, Pusa, 9 (1914): 141–159.
3. PALO, M. A. and C. E. GARCIA. Further studies on the control of leaf-hoppers and tip-borers on mango inflorescence. The Phil. Journ. of Agric. 6 (1935): 425–464.
4. POPENOE, WILSON. Manual of tropical and subtropical fruits. The MacMillan Co., New York, Chap. III, pp. 79–160 (1920).
5. TORRES, JUAN P. Some notes on Carabao mango flower. The Phil. Journ. of Agric. 2: (1931) 395–398.
6 WALLINGTON, RICHARD, et al. Pollination of fruit trees. New York State Agric. Expt. Bull. No. 577 (1929).

ILLUSTRATION

FIGURE 1. A typical perfect floret of Carabao mango.

2. A typical male floret of Carabao mango.

FARMERS' CIRCULAR SECTION

THE FLAX AS A SOURCE OF THREAD FOR LINEN AND SEED FOR LINSEED OIL

[Farmer's Circular 22]

By Tiburcio G. Garrido
Of the Bureau of Plant Industry

THREE PLATES

In considering the cultivation of flax in the Philippines, one could hardly expect that the Islands would be a large producer of the product. There is, however, a good reason to believe that it could be grown here as one of our stable minor crops.

The average value of linen cloths and linen fabrics imported into the Philippines for four years beginning 1930 up to 1934 inclusive was ₱605,040.40 and that of linseed oil during the same period was ₱189,434.60 or a total of ₱794,475.00. This amount does not include the value of imported linen fiber mixed with other vegetable fiber. Our imports of flax-fiber goods alone indicate that we have been contributing a good sum every year to the flax industry of other countries.

This circular presents the cultural methods of the common annual flax, including the methods involved in the manufacture of crude fiber and its uses. The uses of the flax seed is also included here.

TYPES OF ANNUAL FLAX

Two distinct types of annual flax, *Linum usitatissimum,* are now recognized by flax growers: the seed-flax and the fiber-flax. The seed type has short stems and many branches, and is cultivated for seed only (Plate 2, Fig. 1) for linseed oil; whereas the fiber form has fine, long slender stems, few branches and is grown primarily for fiber used for linen (Plate 2, Fig. 2). The seed raised from the fiber type, although produced in relatively less quantity, may also be used for the manufacture of linseed oil.

CLIMATIC RELATIONS AND SOILS

Flax grows successfully in a wide range of latitude, from the tenth to the sixty-fifth north latitude and in a similar range

of southern latitude. The Philippines is located between the fifth and the twentieth north latitude indicating a high probability that the raising of this crop in the Islands is possible.

This plant, especially the fiber flax, requires, during the growing season, a moderate, cool and damp weather, that is, a humid atmosphere and a moderate temperature. Such conditions are found in many places in the Philippines during November, December and January. Accordingly, too much rainfall is inimical to the normal development of the plants while hot and dry weather stunt its growth, thus producing not only small quantity but also poor quality of the fiber. The flax is, therefore, exacting with regard to soil moisture.

The kind of soils for flax is not quite so important as flax may grow well from loam to clayey soils which are practically the types of soils we have. It needs, however, a rather compact or heavier subsoil with greate capacity to retain moisture. It has been found that the heavier types of soil out-yield the lighter soils consistently. Flax is a shallow feeder and it is not hard upon soils for it takes less plant food from the soil than many of the other crops.

CROP ROTATION FOR FLAX

Flax requires a well-planned crop rotation. With flax, a crop rotation is not only intended to improve the soil both as to the chemical and physical properties, but also to control the weeds as well as diseases which prove to be very pernicious to flax crop. In this connection, we should follow the practice of other flax-growing countries, that is, they adopt different periods of rotation from five to ten intervening years between two crops of flax. In the Philippines, flax should follow any clean-cultivated crop that will leave the soil clean and free from weeds. A heavy good crop of upland rice or a well-cleaned or cultivated corn crop and other legumes that leave the soil clean may precede the flax crop.

PREPARATION OF LAND

The land intended for flax planting should be well pulverized and evenly surfaced, free from stubbles, rubbishes and clods. Even or smooth surface of the seed-bed is necessary to have uniform growth of the plants. The subsoil should be made firm and compact before sowing the seeds. This condition can be obtained by passing a heavy wooden roller over the seed-bed one or two times.

PLANTING AND SEEDING

In the Philippines, flax should be planted at the end of the rainy season or during the cool months of the year when there are only some light rain or shower. In many places in the Philippines, November or early in December is the most appropriate time to plant flax, for then the weather is usually moderately cool and damp.

After the seed-bed has been prepared in the manner stated above, the seed is broadcasted by hand and then harrowed into the soil. In harrowing, the native wooden tooth harrow or the bamboo tooth harrow may be used. The seeds should be evenly distributed and should be buried from ½ to 1 inch deep into the soil. Uniform depth of planting is essential for uniform growth of plants which gives good quality and uniform length of the fiber.

After harrowing in the seeds, the wooden roller is passed once or twice again to make the soil surface firm and packed. This is necessary to produce a good stand of the plants because many of the seedlings coming from seeds placed in loose soil will not be able to live or thrive well.

The flax seeds should be planted just thick enough to produce tall, fine and slender straw which yields long, fine, silky and soft fiber (Plate 2, fig. 2). Thick planting prevents profuse branching which lowers both the quantity and quality of the fiber. For fiber production a hectare requires from 70 to 100 kilos of seeds and for seed production from 30 to 40 kilos of seeds. The amount of seeds to be sown depends upon the quality and percentage of germination of the seed. In both cases the seeds for planting should be carefully graded and selected. Only sound plump seeds should be planted.

HARVESTING AND CARE OF SEEDS

The crop can be harvested for fiber in 80 to 90 days and for seeds, in 100 days or more, depending upon the prevailing weather. In warmer days, it takes shorter period.

There are three stages at which flax can be harvested: (*a*) the green ripe; (*b*) the yellow ripe; and (*c*) the full ripe. In the first stage, the plants have attained full bloom but the stems and leaves are yet green. With great care, a very fine fiber can be extracted at this stage. The second stage is the time when the lower one-third of the stems are yellowing, the leaves are beginning to drop off, and some 30 to 50 per cent of the seed

bolls are ripe, yellow to brown in color, yielding about 70 per cent well-developed brownish seeds (Plate 2, fig. 2). These seeds may be used for propagation and for oil production. At this stage, the fiber produced is silky and of medium fine but much stronger than those from the first stage. Most flax for fiber is harvested at this stage. The third or last stage refers to the condition of the plants when all the leaves have dropped off and all the seed bolls matured or the plants are dead. At this stage the stem becomes too woody or hard and the fiber is lignified, losing its silkiness, luster, elasticity and strength, but the amount of seed yield is the greatest. The seed flax is always harvested at this stage.

Pulling by hand is the most common method of harvesting fiber flax. There are three good reasons for this: (*a*) it avoids staining and damaging the fiber; (*b*) it gives better curing of the straw and ripening of the seeds; and (*c*) it produces straw of long fiber.

After curing the straw, the calyx and the seed bolls become brittle, hence, the seeds are easily extracted without injury to both the stem and branches. The seed bolls are crushed into pieces; then by winnowing the seeds may be separated from the chaffs which are blown away together with the lighter, immature and poorly developed seeds. All the plump, sound and normal seeds should be kept dry in cloth or paper bags, placed in wooden box or cigar box which is then stored in cool, dry and dark place or, if possible, kept in seed cabinet or larger boxes.

The flax seeds, like most oily seeds soon lose their vitality when subjected to the warm and moist atmosphere. To prevent loss of germination, they should be kept dry and stored in dry cool place as stated above.

RETTING AND MANUFACTURE OF FIBER

After the stalks have been uniformly dried and cured, they are retted for fiber extraction. Retting is the process by which the fiber is loosened from the woody portion of the stalks. During the process the gummy substances together with the weaker tissues which bind the fiber are dissolved.

There are three methods of retting flax straw; namely, the chemical method, the water retting, and the dew retting. Up to the present time, there is no successful retting by means of chemicals; they proved either expensive or destructive to the

flax fiber. Water retting has been used to a certain extent in some places in Belgium, Russia, and the United States. The straw in bundles are placed for some time in water in the tanks, reservoirs, or in flowing rivers or streams until the fibers may be easily separated. This method is rather delicate, needing a very close supervision by experienced hands.

The dew retting is the most extensively used by the fiber-flax growing countries. This process is the most practical method to use here in the Philippines. The threshed straw is evenly spread in thin layers in straight rows on a moist grassy meadow. An evenly growing grass should be preferred to insure uniform retting. The bacterial action facilitated by the presence of moisture from the dew and rain tends to dissolve the gummy substances and the weaker tissues which bind together and keep the fiber tissue to cling to the woody portion of the stalks.

The flax straw is completely retted in 15 to 20 days during the drier months and in 10 to 15 days during the rainy days. Usually the straw is turned over only once during the process. As soon as the cuticle can be separated mechanically and the separation of the fiber bundles from the rest of the cortex becomes easy, the retting may be considered complete.

Breaking, scutching, and hackling.—Thoroughly dried well-retted straw looks bright with a peculiar sweet odor (Plate 3, Fig. 1). The wood and the outer skin become harsh and brittle while the fiber is more or less elastic and tough. The straw in small convenient size bundles is pounded with wooden mallets, breaking the wood to short small pieces called shives (Plate 3, Fig. 1). These shives are all removed by combing or scutching. The scutched fiber is still reduced to finer divisions by hackling process (Plate 3, Fig. 2). Breaking, scutching and hackling are done by machinery in the United States and other countries, although it is admitted that the best work is done by hand. With a well-graded hackling, the fiber may be divided into the desired fineness for the spinner.

FLAX PRODUCTS

The fiber is used for the manufacture of high-grade linen cloths for garments, napkins, table runners, towels, handkerchiefs and strong sailcloths; twine for the manufacture of rope and cordage and strong sewing threads for shoe manufacture and fine embroideries. Strong grade linen cloth was made into wings for aeroplanes during the World War. From linen,

a pulp is obtained which is made into paper of varying qualities from thick ones to a very thin kind used for the manufacture of wrappers for costly cigarettes.

The seed of this plant produces valuable oil, the linseed oil, used in making linoleum and oil cloth, for medicinal purposes, and as ingredient of paint and varnishes.

COST OF PRODUCTION AND CASH RETURN

For obvious reasons, the cost of production and cash return should be included in this circular. In the following two tables the figures represent conservative estimates of the cost of raising and manufacturing crude fiber and cash returns from one hectare of fiber flax. Table 1 shows the itemized expenses of the farmer and the possible cash returns from the straw, if his business is to raise only the straw for the manufacturer. From these estimates, the farmer can realize a net income of ₱52 aside from the possible labor income of not less than ₱48 per hectare.

If the farmer manufactures the crude fiber his labor income will be increased from ₱48 to ₱104 and his net income to ₱127.30 per hectare.

On the other hand, as shown in Table 2, the manufacturer of crude fiber can get from three tons of straw a net income of ₱75 besides the labor income of ₱56.

ACTUAL AND ESTIMATED YIELD FROM THREE STATIONS

Table 3 shows the days of maturity, the actual and estimated yield of the two varieties of both straw and seed per hectare as tried in plot tests in three stations in the Philippines. These data were obtained from the second year of their introduction here. It is to be noted that per average the Riga grows taller by 4.2 cm., produces straw 0.53 of a ton more per hectare and gives 0.89 of a kilo more of crude fiber per hectare (see "Flax in the Philippines." The Phil. Jour. of Agric. Vol. 7. No. 2, p. 231, 1936), than the Dutch. The latter, however, produces 16.66 kilos of seeds more per hectare than the former. The range of maturity is not very significant because both of them mature almost at the same time. The results indicate that Riga outyielded the Dutch in all the stations where trials were made. In this connection, it seems that Riga is more productive for fiber productions than the Dutch so that if we are concentrating our effort to produce straw for fiber, then this variety is more profitable to grow than the Dutch.

TABLE 1.—*Farmer's expenses and cash returns per hectare*

Preparation of land (cleaning, plowing, harrowing, rolling and leveling)	₱30.00
Seeds, 80 kilos, at ₱0.25 per kilo	20.00
Planting (broadcasting, harrowing in and rolling)	4.00
Harvesting, stocking, and curing	14.00
Total expenses	₱68.00
Gross returns: Yield per hectare, 3 tons of straw, at ₱40 per ton	120.00
Total expenses	68.00
Expected net income	₱52.00

TABLE 2.—*Manufacturer's expenses and cash returns per hectare*

Three tons of straw, at ₱40 per ton	₱120.00
Retting, spreading, and bunding	6.00
Breaking, scutching, hackling and bailing	40.00
Miscellaneous other expenses	10.00
Total expenses	₱176.00
Long fiber, 6.82 piculs, at ₱34 per picul	232.00
Two or short fiber, 2.27 piculs, at ₱8.50 per picul	19.30
Gross returns	251.30
Total expenses	176.00
Expected net income	₱75.30

SUMMARY AND SUGGESTIONS

1. Fiber flax is a short-season crop harvested in 80 to 90 days from the date of planting.

2. It needs moderate, cool and damp or humid atmosphere. Too much rain is destructive to the plants. Slight rain or shower favors the vegetative growth of the plants.

3. Flax requires a well-planned rotation of crops in order to control weeds, pests and diseases. The flax crop should follow pasture, meadow or clean-cultivated crops.

4. Flax requires a firm and packed seedbed. This helps germination and maturity.

5. Only clean, plump and well-matured seeds should be planted. A portion of the field should be set aside for seed production, for propagation or the fully developed brownish seeds which are produced at harvesting the crop for fiber could also be used for propagation purposes. Any weed growth should be removed to avoid admixture of weed seeds, and the seeds should be cleaned and thoroughly graded.

TABLE 3.—*Showing the days of maturity, actual and estimated yield of straw and seed of the two varieties of flax grown in the Central Station (Manila), Economic Garden (Los Baños, Laguna), and Tanauan Station (Batangas), in 1935–36.*

Station	Variety	Days of maturity 50 per cent matured bolls	Actual area planted	Straw			Seed	
				Average length at harvesting time	Actual yield	Estimated yield per hectare	Actual yield	Estimated yield per hectare
			Sq. M.	*Cm.*	*Kilos*	*M. T.*	*Kilos*	*Kilos*
Central Station, Manila	Riga	79.00	35.00	81.03	11.90	3.40	.95	270.00
Economic Garden, Laguna	Riga	90.00	200.00	76.20	56.80	2.84	5.60	280.00
Tanauan Station, Batangas	Riga	88.00	50.00	64.32	14.30	2.86	1.60	320.00
Average		85.66		73.85	27.66	3.03	2.716	290.00
Central Station, Manila	Dutch	85.00	35.00	76.10	10.35	2.96	.98	280.00
Economic Garden, Laguna	Dutch	91.00	25.00	71.80	5.03	2.01	.75	300.00
Tanauan Station, Batangas	Dutch	88.00	50.00	61.05	12.60	2.52	1.70	340.00
Average	Dutch	88.00		69.65	9.33	2.50	1.14	306.66
Do	Riga	85.66		73.85		3.03		290.00
Difference		2.34		—4.20		—.53		16.66

6. Seeds should be set from ½ to 1 inch as deeper seeding may not grow up.

7. The preliminary tests made in our stations in the Philippines show an average yield for two varieties tested, the Riga and Dutch, 6.82 piculs of scutched fiber and 2.27 piculs of tow or short fiber per hectare. This yield compares favorably with the average yield of other flax-growing countries. (Reference can be made in published article, "Flax in the Philippines," The Philippine Journal of Agriculture, Vol. 7, No. 2, pp. 229–241, 1936.)

8. According to a conservative estimate of the cost of production and cash return from one hectare of flax fiber, a net profit of ₱52 for the farmer and ₱75.30 for the manufacturer may be realized.

9. Flax would make a good minor cash crop in the Philippines, but if the cultivation of this crop is extended here, we should follow the examples of other flax-growing countries, like the Soviet Russia, Belgium, Netherlands, Latvia, United Kingdom and other flax-producing countries, where the producers, small farmers, grow the flax and sell the straw to the factory where the straw is retted and the crude fiber is manufactured.

ILLUSTRATIONS

1

2

PLATE 1.

PLATE 2.

1 2

PLATE 3.

CULTURE OF EDIBLE MUSHROOMS IN THE PHILIPPINES

[Farmers' Circular 28]

By Feliciano M. Clara

Chief, Plant Pathology Section
Bureau of Plant Industry

FIVE PLATES

Mushroom is not so readily raised as ordinary vegetables. The peculiarity in the requirements for its growth and the execution of the methods of culture, varying according to people, conditions and the locality, may sometimes cause failures. More so in the Philippines where no previous systematic study on mushroom culture has ever been made. The only scanty information and attempts at cultivation are based upon the appearance of this vegetable as it occurs in nature during certain season of the year. The demand for this much desired delicacy is supplied by canned and dried mushrooms imported from foreign countries.

A great deal of the success in mushroom growing is dependent upon five main requirements: (1) good spawn, (2) suitable materials or substrata for beds, (3) proper construction of beds and spawning, (4) proper supply of moisture in watering the beds, and (5) control of diseases and pests attacking mushrooms.

The method of cultivating mushrooms contained in this circular is based upon the results of the investigations conducted by the Bureau of Plant Industry.

THE SPAWN

Mushroom spawn is the material with which the plant is propagated. There are two kinds of spawn—pure culture spawn and wild spawn or "virgin spawn." The former is a prepared pure culture of the fungus in a suitable medium, while the latter is a material from the field or a bed which contains mycelium and spores of the desired mushrooms such as, for instance, rice straw on which edible mushrooms may be found growing. Where pure culture spawn is not available the "virgin spawn"

may be used. In countries where mushroom growing has reached a very high degree of development, the pure culture spawn is used (Plate 2). Its preparation is a business by itself conducted by mushroom spawn dealers. It requires laboratory methods and equipment.

In the Philippines there are no mushroom spawn dealers. There are some imported spawns from foreign countries, but they are not suitable to Philippine climate. Unless they are planted in air-conditioned mushroom houses with regulated temperature and moisture, or in regions with semi-temperate climate like Baguio, they are not expected to grow. Caves such as those in the abandoned mining districts may also be found suitable for this type of mushrooms. There is a kind of spawn imported from China which is not pure culture and its true worth under Philippine conditions is not yet known. This spawn is the rice straw of which the beds are made. After the mushroom is harvested, it is gathered and used for spawning new beds. Spawn of Philippine edible mushrooms may be obtained in a similar manner and used for planting new beds especially when no sufficient pure culture spawn is obtainable.

In the method described in this circular, both pure culture and wild spawns of the Philippine edible mushroom of the type *Volvaria esculenta* are used. The pure culture spawn is more advantageous than the wild spawn which appears to be uncertain as to its productivity.

A limited quantity of pure culture spawn of Philippine edible mushroom is prepared by the Bureau of Plant Industry (Plate 2). Some of these have already been distributed for coöperative trial plantings. The number of people interested in mushroom growing is increasing and so is the demand for spawn which sooner or later will bring about a new industry for spawn dealers.

THE BEDS

Location.—The beds should be located near a good source of water supply. Flat lands and rice paddies after dry season harvests may be found convenient for this purpose. Lands protected from strong winds such as those with natural wind breaks, hill sides, near bamboo trees or any planting that protect the beds from strong winds, offer suitable locations since moist condition may be more readily obtained with such protection than in the open fields. During the months of June, July, August, September and October open fields may be found suitable for during these months the conditions are suitably humid

for mushroom growth. Prolonged heavy rains are as injurious to mushroom growth as the dryness that follows the rainy season.

Materials for beds.—There should be a good supply of dry rice straw to be used in making beds. Abacá fiber refuse, banana stalks, tobacco midribs, old gunny sacks, and abacá mat trimmings (Plate 3) are useful as layers for spawning and as mixtures with rice straw in making the beds. The rice stalks usually left in the paddies after harvesting are suitable materials and may be superior to the ordinary straw with the leaves. Where tobacco midrib is procurable it may be mixed with straw about 2 to 7 or 3 to 7 by parts. All of these materials should be well dried before using them for making beds. The rice straw composed of the stalks should be used as the main part of the beds and the finer ones with the leaves as covers or final layers.

Construction of beds and spawning.—The beds may be constructed with any desired length. The height is about one meter or slightly less from the level of the ground and about 90 centimeters wide. The first step is to make a bed of garden soil preferably clay loam, about 25 centimeters from the ground level. The soil should be pressed well and leveled on the surface. This foundation of the bed can be well packed by moistening the soil during construction. The surface of the bed is sometimes fashioned like a trough by making a dike 15 centimeters wide, and 5 centimeters thick all along the edges. In places where no pipe system for water supply is available a canal 30 centimeters wide and 10 centimeters deep and from 32 to 40 centimeters away from the bed should be made for every two beds.

As soon as the soil foundation is ready, spawning should be done. Before planting the spawn, a thin layer of any of these materials—abacá fiber refuse, dry banana leaf sheats, old abacá sacks or mats, gunny sacks that are usually thrown away—should be used as first layers on the top of the soil part of the bed. These materials should be wet by soaking or sprinkling before placing them on the bed. This method gives a very favorable growth for the fungus. The spawn is planted on this layer along the edges 5 to 6 centimeters from the sides and 15 to 30 centimeters apart. In planting, the spawn (Plate 2) is taken out of the bottle by picking it with forceps or any convenient tool or by breaking the bottle. Care should be taken not to tear the spawn into very small lumps or pieces. It is then divided into pieces about 5 or 6 cubic centimeters a piece.

The pieces of spawn may be planted on the beds as pieced out of the mass. If a good supply of spawn is available it is better to use bigger pieces and make the distance closer. In case of wild spawn, it is planted by spreading it evenly on the bed.

After planting the spawn, wet straw is laid and pressed evenly on the bed. When the layer of straw is about 15 centimeters thick another spawning may be done in the same manner as in the first layer. Wet straw is gain piled up and pressed well by stepping on it until the bed is about a meter high. It is necessary that the straw is well packed. An idea of laying the straw and the final shape of the bed may be gained from (Plates 4 and 5).

Watering and care of bed.—During summer, which is not a season for mushroom, it is possible to raise this vegetable by providing the beds with the right amount of moisture. After planting the spawn the beds should not be watered for one week. Watering may be done two or three times a week thereafter. The soil should be kept moist by allowing some of the water from the top of the bed to drip slightly or sip down on the sides. The canals are occasionally flooded when the surrounding is very dry. Excessive or standing water will destroy or prevent the growth of mushrooms. Good judgment gained from experience determines the amount of water needed and the time it is needed. In the rainy season, particularly during the most favorable weather for mushroom growth (June, July, August, September and October), watering may not be necessary at all. Watering during the dry season should be done regularly and carefully until the mushrooms appear in the "button" stage. The soil should be kept moist by judicious watering. As soon as the "buttons" are noticed, watering should be slight because plenty of water destroys the young mushrooms and favors the development of diseases. Spraying with fine showers is sufficient when the beds are bearing. If a sprayer is not available, sprinkling to allow moistening of the sides is sufficient. If it is desired to grow mushrooms all the year round, the beds should be under some kind of roof to prevent too much water during rainy season as well as too rapid drying during summer. Galvanized sheet iron may be used as covers instead of a roof.

Harvesting.—Seventeen to 20 days from the date of spawning, a good crop of mushrooms may be ready for harvesting. Sometimes the first flush appears in 11 days. They should be harvested while young (Plate 3). In harvesting, care should be taken not to injure or disturb the mycelium and the neigh-

boring "buttons". At times there are several plants in a clump with several "buttons" adhering or growing adjacent to the base of the clumps. The plants to be harvested should be separated or picked up carefully with the aid of a knife. The plants should be twisted after having a firm hold of the base with the thumb and fingers. In this manner the base or stump is pulled out with the mushrooms. If stumps or bases are left on the beds they decay and serve as a source of infection and infestation.

Diseases and pests.—Mushrooms are subject to a number of destructive diseases and pests. Practically nothing is previously known about mushroom diseases and pests in the Philippines. This is of course to be attributed to the absence of the industry and studies along this line. In the mushroom projects of this Bureau, diseases and pests appeared just as soon as the work was in progress. The disease known in other countries as bubbles caused by *Mycogone perniciosa* is very destructive. The "plaster mold" or "flour mold," *Monilla fimicola* and another fungus very similar to truffles fungus, *Pseudobalsamia microspora* are also apparently encountered.

Among the pests mites, millipeds, grubs and earthworms are very common. They cause much destruction to the "buttons" and the growth of the mycelium. Mice and lizards are other pests to reckon with. The latter is particularly very voracious. It eats mushrooms in the "button" and matured stages.

The use of tobacco decoction for the control of the insects, soil sterilization for the fungi, and fencing the mushroom field with wire will greatly minimize and in some cases may completely check damages caused by these enemies. Derris powder or decoction may also be found useful in the control of the pests. Saturated solution of lime used in the soil of the beds before planting greatly minimizes the damage caused by earthworms.

ILLUSTRATIONS

PLATE 1

Mushroom (*Volvaria esculenta*) grown in a mushroom house of the Bureau of Plant Industry.

PLATE 2

Mushroom spawn as prepared by the Bureau of Plant Industry.

PLATE 3

Side view of a mushroom bed made of abacá waste or trimmings from the Textile Laboratory. Note abundant growth of mushroom.

PLATE 4

Side view of a number of mushroom beds with mushrooms. These beds are under ordinary conditions outdoor at the Central Experiment Station, Manila.

PLATE 5

A perspective view of one of the beds under a glass roof. Note the mushrooms growing on the soil base of the bed.

PLATE 1.

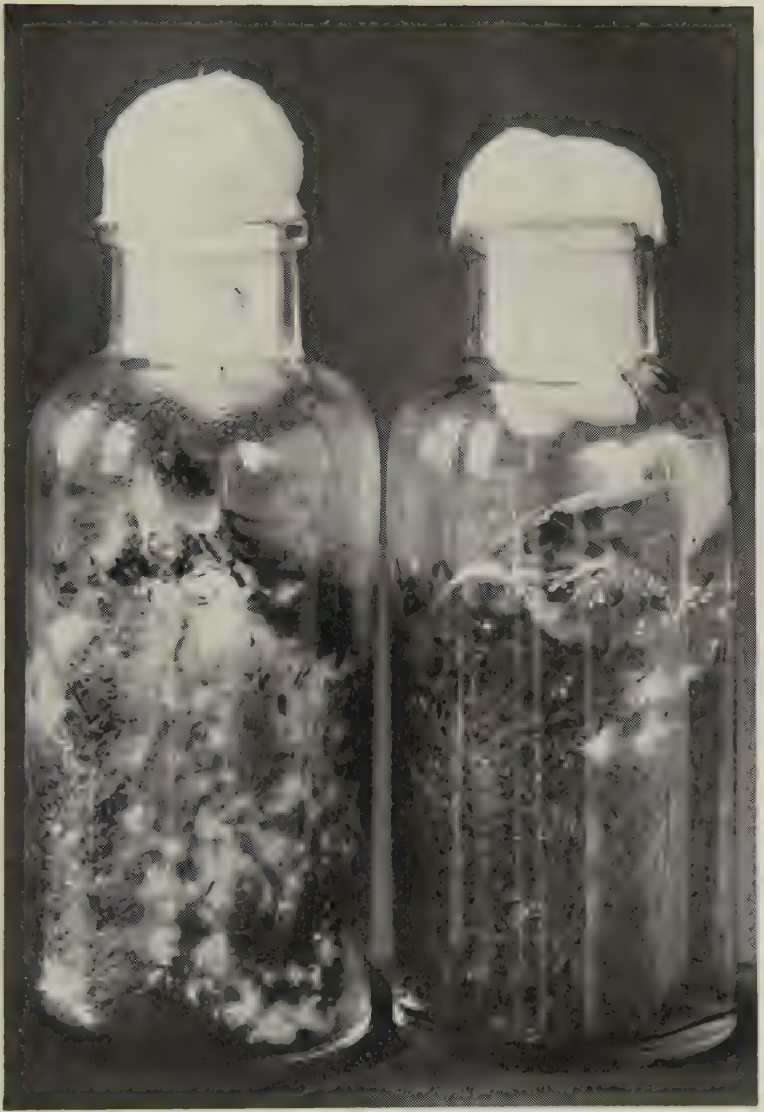


PLATE 2.

PLATE 3.

PLATE 4.

PLATE 5.

THE PROPAGATION OF PLANTS

[Farmers' Circular No. 40]

By SIXTO L. SISON and EPITACIO A. LANUZA

Assistant Agronomists

SEVEN PLATES

Plants may be propagated in two ways: (1) sexually or by seeds and spores, and (2) asexually or vegetatively.

By sexual propagation is meant the reproduction of plants by means of seeds and spores; e. g., the propagation of cereals as palay and corn; fruit trees as mango, caimito, etc.; legumes like mongo and cowpeas; ornamental plants like coreopsis and zinnia. Ferns, both edible and nonedible ones, are by nature propagated by spores.

Asexual or vegetative propagation is the reproduction or perpetuation of plants through the use of a growing or vegetative part either naturally, such as by means of suckers, bulbills, tubers, rootstocks, sets, stolons, corms or cormels, etc.; or artificially, like for instance by means of cuttings, layering, inarching, marcotting, budding, and grafting.

Since vegetative propagation or asexual reproduction is one which is least understood but one which is very important especially in orcharding, this paper will deal mostly on this method. At the outset, mention could be made of the advantages on this method of propagation which are as follows:

1. It is the most practical and surest means of perpetuating the desirable characters of parent plants. In the case of reproduction by seeds, the resulting plants in most cases do not come true to type or do not have the same desirable characters as the parent plants.

2. In the case of budded or grafted plants the stock best adapted to the soil and climate of a given place, congenial for the scion and most resistant to certain pests and diseases, can be used; thus a fruit grafted upon the proper stock can be cultivated in a region where cultivation on its own roots would be hardly possible, if not altogether impossible. Good stocks impart a certain degree of vigor and productivity to resultant

trees. The establishment of the grape industry in the New England States of the United States has been attributed to this method of plant propagation. When rooted cuttings of grapes, producing a heavy yield of luscious fruits, much in demand in the New England States, were first imported from Southern France, the venture was a total failure; because the roots were attacked by a certain root disease prevalent in that region. However, by grafting scions of the imported varieties to native stock resistant to the said root disease, the industry was successfully established.

3. Vegetatively propagated plants bear fruits earlier and therefore yield profits earlier. Many seedling trees are not only poor producers but also sterile.

4. Orchards grown vegetatively are made more uniform both in growth and in the quality of fruits; the latter being an important consideration in marketing.

5. Because of the nature of growth of vegetatively propagated plants, pests and diseases are easy to control, too much wind injury obviated, and gathering of fruits made easier.

There is only one alleged disadvantage of vegetatively propagated plants and that is they do not grow as big or as fast as seedling plants. This assertion, however, is not wholly true as grafted carabao mango plants in northern Occidental Negros and eastern Batangas grow bigger and faster than seedling trees of the same age but they seldom bear fruits or not at all. The probable reason why grafted trees do not grow as fast as seedling trees is because grafted trees bear fruits earlier. It is a well-known fact that the production and maturing of a fruit, especially in the case of heavy producing carabao mangoes and Batangas mandarins, is such a very exhaustive process that after one season of very heavy fruiting, hardly any food supply is left even for growth purposes so that the growth of a tree is delayed even as much as one whole year. Thus, while early producing grafted mangoes for example grow once only every two years seedling mangoes are undisturbed in their growth habits and hence after a period of time are even twice as big as grafted trees.

PROPAGATION BY CUTTINGS

Cuttings may be divided into: (1) root cuttings, made from roots as in the case of the rimas; (2) stem cuttings, made either (*a*) from the tender immature parts of plants and called soft-

wood cuttings as of gummamela, San Francisco, etc., or (*b*) made from the mature growth and called hardwood cutting as in the case of certain ornamental plants like Bougainvilla, Campanilla, etc., (3) leaf cuttings made from the leaves, as in the case of the Begonia plant.

All of the above cuttings may be rooted in peat moss, which may be obtained from nurserymen and seed dealers. In its absence, however, clean, medium coarse sand or sandy loam soil could be used for root, softwood, and leaf cuttings. For hardwood cuttings, ordinary loam soil which crumbles easily should be used. In all cases, never use manure so as to prevent infection of the cut portions. A bed or frame containing the above media may be used. In the case of root and hardwood cuttings, the bed or frame should be filled 20 centimeters deep with the required media and in the case of softwood and leaf cuttings, about 6 centimeters deep.

Root cuttings to be used should be 1 to 4 centimeters in diameter and sawed off into lengths of 20 centimeters each and the ends cut smooth with a sharp knife. The topmost cut should be painted with white lead or coal tar. Hardwood cuttings to be used should be about 20 centimeters in length and for softwood cuttings around 6 centimeters long and taken from the tender, immature, terminal ends of the twigs. In both cases trim off about two-thirds of the leaves. The cuttings should be placed diagonally, leaving about one-fourth of each cutting projecting above the surface and the media packed well so as to leave as little air space as possible between the media and the cuttings. In the case of root cuttings the big end of each cutting should be placed topmost.

Begonia is a good example of plants propagated by leaf cuttings. In this case, a leaf is divided into 2 or 3 parts each containing big veins and then pinned on the media of either moss or sand.

Precaution must be taken that in no case, from the time the cuttings are severed from the parent plants to their final planting in the frame or seed bed, should the cuttings be bruised or allowed to dry and wilt.

When the cuttings have rooted well and grown to about 8 to 12 inches high (for such plants as begonia the criterion is the development of 3 or 4 leaves), they should then be transferred to the nursery for some time until sufficiently well established to be placed in the orchard or garden. Plants like begonia should directly be transferred in pots or in permanent places.

PROPAGATION BY LAYERING AND MARCOTTAGE

Layering is the rooting of a twig or branch while still attached to the parent plant and is done by pegging to the ground a notched branch or twig until it has rooted and is able to maintain itself before finally cutting off such branch from the parent plant. Because of its inconveniences, there being but very few branches close enough to the ground which may be pegged without breaking, this method of propagation is seldom, if at all, practised at present. Instead, marcotting or air layering, that is, causing the branch to root while on top of the parent plant, is being commonly practised.

For marcotting, a good-sized, medium-matured branch is selected. A ring of bark one-half inch to three inches in length (depending upon the size of the branch) is cut off making sure that the cut does not extend farther than the cambium layer. Scrape off all remaining bark so that there will not be any possibility for the cut to heal over and produce a new bark. Allow the cut portion to remain exposed for a few days or a week so as to let the cuts callouse. Then using a sandy loam soil or soil that easily crumbles with a slight pressure of the hand but one that does not contain animal manure so as to prevent infection of the cut portion, cover the cut portion with about two or three inches of soil all around. This soil should be held in place with coconut husk, well pounded so that proper irrigation and aëration can go on. Gunny sacks or any other convenient material may also be used. Tie tigthly with any strong tying material to prevent falling off. When the branch has already well rooted (and the roots are already properly matured and hardened), the branch may be severed with a pruning saw and the severed portion painted with white lead or coal tar to prevent infection. Coir dust instead of soil may also be used in lieu of the soil.

To avoid much expense in watering marcotted branch, propagation should be made at the beginning of or during the rainy season.

PROPAGATION BY GRAFTAGE

Grafting is the process of transferring a part of a plant, which is to be propagated or perpetuated (called the scion or bud) into another (called the stock) which is the plant on which the operation is to be performed, with the intention that the scion and the stock shall grow together. For our purposes this method shall include budding also.

It must be remembered that grafting is not an improvement in itself but the means by which an improvement is effected; so that in order to produce plants that are of superior or desirable qualities, the scions to be used should come from plants possessing the desirable qualities.

In order that the scion or bud and the stock may grow well together as one plant, there must be a close affinity between the two. In general, scions of a given species may be grafted or budded into another plant of the same species, as for example, buds of sweet oranges may be budded on sour orange stocks; scions of a given species into another in the same genus, as for example, pineapple orange on Batangas mandarin stock.

The season at which the operation is performed apparently exercises some influences on the facility with which the union takes place. Many practical nurserymen believe that the best time to perform this operation is just before the flowering or fruiting season of each particular fruit tree, as during that time, the twigs and branches have much stored food materials which can be utilized for growth purposes. In mangoes, for example, this assertion seems to hold true as more successes in grafting have been obtained about the middle of the dry season than at any other period of the year.

1. SHIELD BUDDING

a. Rules to follow:

(1) The budding knife to be used must be clean and sharp.

(2) The stocks must be in such condition that the bark separates readily from the wood, allowing the easy introduction of the bud, and should have at least a diameter of one centimeter or more but not over matured. A plant properly taken care of and of vigorous growth should have attained this size in about one year.

(3) Proper budwood: The selection of the budwood, with the exception of a few species, is perhaps the most difficult problem for the beginner. (The kind of budwood to use and the stock on which they should be budded or grafted for each species is mentioned at the end of this article for guidance.)

(4) The budwood should not be allowed to dry from exposure to the air and sun.

(5) In cutting the bud, be sure that there is no break or tear in the tissues.

(6) In some species, the similarity of the age and appearance of the scion and the stock at the point of insertion is of prime importance, like for example in the case of mango, cacao, and santol.

(7) The bud should be inserted immediately after it is cut and should be tied at once with a conveniently good tape which

may be made by cutting crosswise into strips of about 20 to 25 centimeters long a fine-meshed cotton cloth previously washed to remove starch and dried. Then roll evenly one or two strips rather fairly tight on a previously prepared rounded bamboo or any other clean stick of about 30 centimeters long. Immerse these cloths 10 to 20 minutes in the following melted mixture of:

Beeswax	1 kilogram
Red resin	2 kilograms
Beef "suet" (sebo)	150 grams

taking care not to overheat. Then remove to cool off. This tape is then ready for use.

(8) No water or impurities should be allowed to enter the bud.

b. Operation:

An inverted T cut, 3 to 4 centimeters or more in length, is made, through the bark and as deep as the cambium layer, in the stock. The cut should be made as near the ground as possible or at least about 20 centimeters above the ground, for in this way the buds have the tendency to sprout more readily than when they are inserted higher up in the stock. This will also save much time later in removing water sprouts. To facilitate insertion of the bud, loosen up the bark just sufficiently to allow it (the bud) to easily slip into place. In most stocks the proper loosening is easily made with a slight upward twist or swerve of the knife blade in making the vertical or cross cut. Next, a bud is cut, not less than 2 centimeters long, taking care not to cut the bud too thin and that no break or tear is made in the tissues. In thick-barked and rapidly growing species, the buds should be cut large with an ample wood-shield as otherwise, they are in danger of being grown over by the callous after they have taken and before the bud growth has started. After this cutting the bud is inserted in the cut and tied firmly, but not very tightly as to strangle the bud, with grafting tape, beginning at the point of insertion and covering the whole bud so that no water can enter.

After about two weeks, if a good callous has formed around the bud shield, which often is the case, un-wrap the tape to expose the bud. If the bud is living, the tape must not be entirely removed as opening of the bark may cause rotting to occur. Then make a notch or a cut about one-third through the stock at a height of about 6 to 8 centimeters above the bud union and opposite the developing bud.

Make a weekly inspection, or so, deepening the notch on the stock each time so as to hasten the growth of the buds. When

the growth of the bud is already about 5 centimeters high, loop the stock at the place of notching. When a growth of about 30 to 50 centimeters of the bud is attained, cut off the stock smoothly and slantingly with a sharp knife just above the union and paint the cut with a good paint for the purpose. Experiences show that asphaltum linseed oil paint is the best for this purpose. White lead may also be used. In fact for general purposes white lead is good. Coal tar has a slight burning effect on the tree. Asphaltum-linseed oil is prepared by mixing linseed oil and asphalt. The mixture is boiled so that the consistency is that of a white lead paint. The formula is: Asphalt—1 kilogram; linseed oil—350 grams. All sprouts on the stock should be rubbed off as soon as they appear. The budded plants will be ready for the orchard when about a meter high or more.

2. *Cleft grafting.*—This is done by cutting off the stock at right angle at the point where it is desired to insert the scion. A wedge-shaped scion 7.5 to 12.5 centimeters long, carrying three or four buds is then made. The stock is split in the middle with a grafting knife just long enough to properly insert and fit the scions. In inserting the scions into the stock, the cambium layers of the stock and the scion should be placed in close contact. Tie with grafting tape to cover and protect the wounds well from rain, dew, and fungi. The scion and part of the stock are covered with wet moss or banana leaf sheaths to keep the scion from drying. Remove the moss or leaf sheaths when the scion begins to grow, usually after 3 weeks.

Proper budwood and stock to use in budding and grafting for each of our important commercial fruit trees as given by P. J. Wester and Jose de Leon:

Avocado.—Use tender to mature, but green, smooth-petioled budwood; cut the buds 3.5 to 4.5 centimeters long; age of stock at point of insertion of bud unimportant. But on avocado stock of the same species.

Caimito.—Use fairly mature to well-matured, brownish to grayish, non-petioled scions. Insert the scions in the stock at a point approximately of the same appearance as the scions. Graft on caimito stock of the same species.

Citrus.—Use fairly mature to well-matured, petioled, green and smooth, preferably spineless and round budwood. Cut the bud 2.5 to 4 centimeters long. Age of the stock at point of insertion of bud unimportant. Stocks to use:

Bud mandarin on Batangas mandarin and orange stock.
Bud oranges on Batangas mandarin and orange stock.

Bud pummelo on Batangas mandarin and orange stock.
Bud lime on Batangas mandarin and sour orange stock.
Bud grapefruits on Batangas mandarin and rough lemon stock.
Bud lemons on rough lemon stock.

Lanzon.—Use well-matured scions. Insert the scions in the stock 6 to 10 centimeters above the ground, when at that height it is 7 to 15 millimeters in diameter. Graft on lanzon stock.

Mango.—Use non-petioled, mature, smooth, green scions from the first, second or third flush. Insert the scions in the stock at a point approximately of the same age and appearance as the scion. Graft on mango stock of the same species.

Santol.—Use non-petioled, fairly mature turning brownish, grayish, and rough, rather slender scions. Insert scions in stock at a point of the same age and appearance as the scion.

Explanation of terms:

Petioled budwood.—Budwood cut at the time of budding with leaves still attached. The petioles are cut off close to the bud before using budwood.

Non-petioled bud-wood.—Budwood which, when taken, has no more leaves, or budwood whose leaves have been cut off or removed sometime in advance prior to and about two weeks before cutting of buds. This is done to induce the dropping of the leaves and the formation of a well-headed leaf-scion.

Scion.—is the bud or branch which is inserted into the stock. This eventually becomes the shoot of the tree.

Stock.—that portion of the plant to which scion is inserted. This becomes the root of the future trees.

Spores.—equivalent to seeds of higher plants like reproductive body of ferns, a primitive reproductive body.

REFERENCES

1. LANUZA, E. A. The Propagation of Plants with Special emphasis on Fruit Trees. La Linterna. 1935. 1: (44): 35, 45 and 1 (45): 38–39.
2. LEON, JOSE DE. 1932. Citrus growing in the Philippines. Bureau of Plant Industry.
3. WESTER, P. J. 1920. Plant Propagation and Fruit Culture in the Tropics. Bureau of Agriculture Bulletin No. 32.

ILLUSTRATIONS

Plate 1

Different kinds of scions; (*a*) non-petioled and (*b*) petioled. (2) Budding tape.

Plate 2

Different stages in budding: (*a*) cutting a shield bud, (*b*) shield bud, (*c*) stock ready for insertion, (*d*) bud inserted, (*e*) budded and tied, (*f*) bud partially exposed after about two weeks. Note notching at point N. (*g*) lopping (point L) to induce growth of scion (*k*) budded plant. Note method of cutting off of the seedling top.

Plate 3

Stages in cleft-grafting: (*a*) stock cut and split ready for insertion; (*b*) scion cut and wedge-shape ready for insertion; (*c*) scion inserted in stock; (*d*) cleft-grafted and tied.

Plate 4

(*a*) Pruning knife; (*b*) Budding knife; (*c*) Grafting knife; (*d*) pruning shear.

Plate 5

(*a*) Layering: Note pegging P.; (*b*) Inarching: B–*a* branch of mother plant, S—seedling.

Plate 6

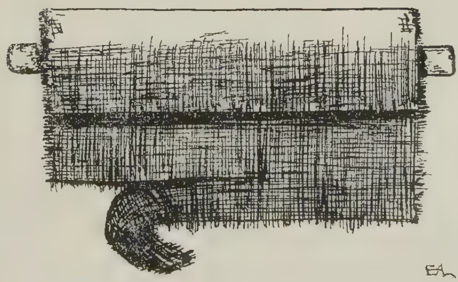
Marcotting: (*a*) marcotted branch, (*b*) portion of a branch with bark removed preparatory to wrapping, (*c*) marcotted and wrapped.

Plate 7

Cuttings: (*a*) soft-wood cutting, (*b*) hard-wood cutting, (*c*) root cutting, (*d*) leaf cuttings. Note the method of cutting a leaf into three parts.

a *b*

1



2

PLATE 1.

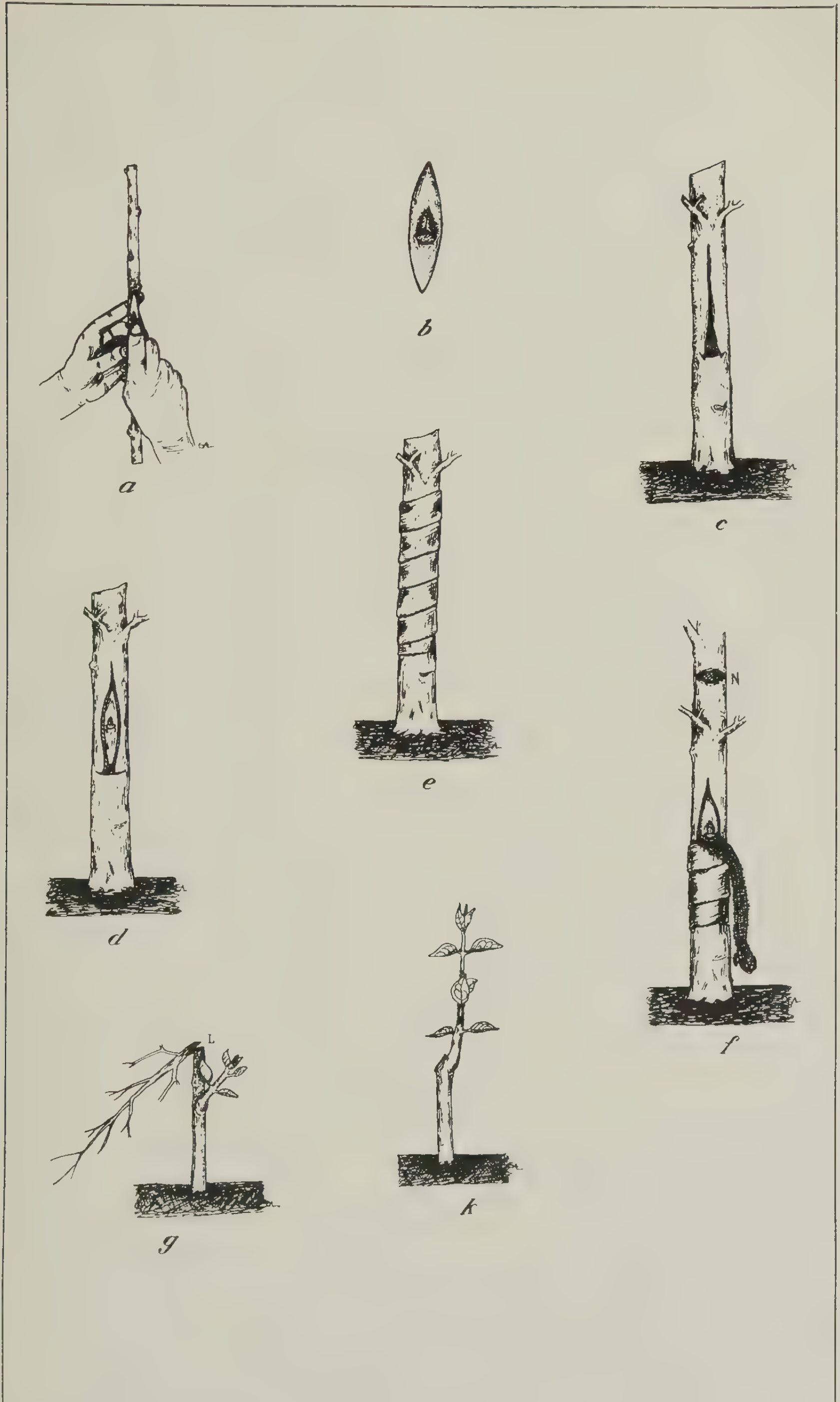


PLATE 2.

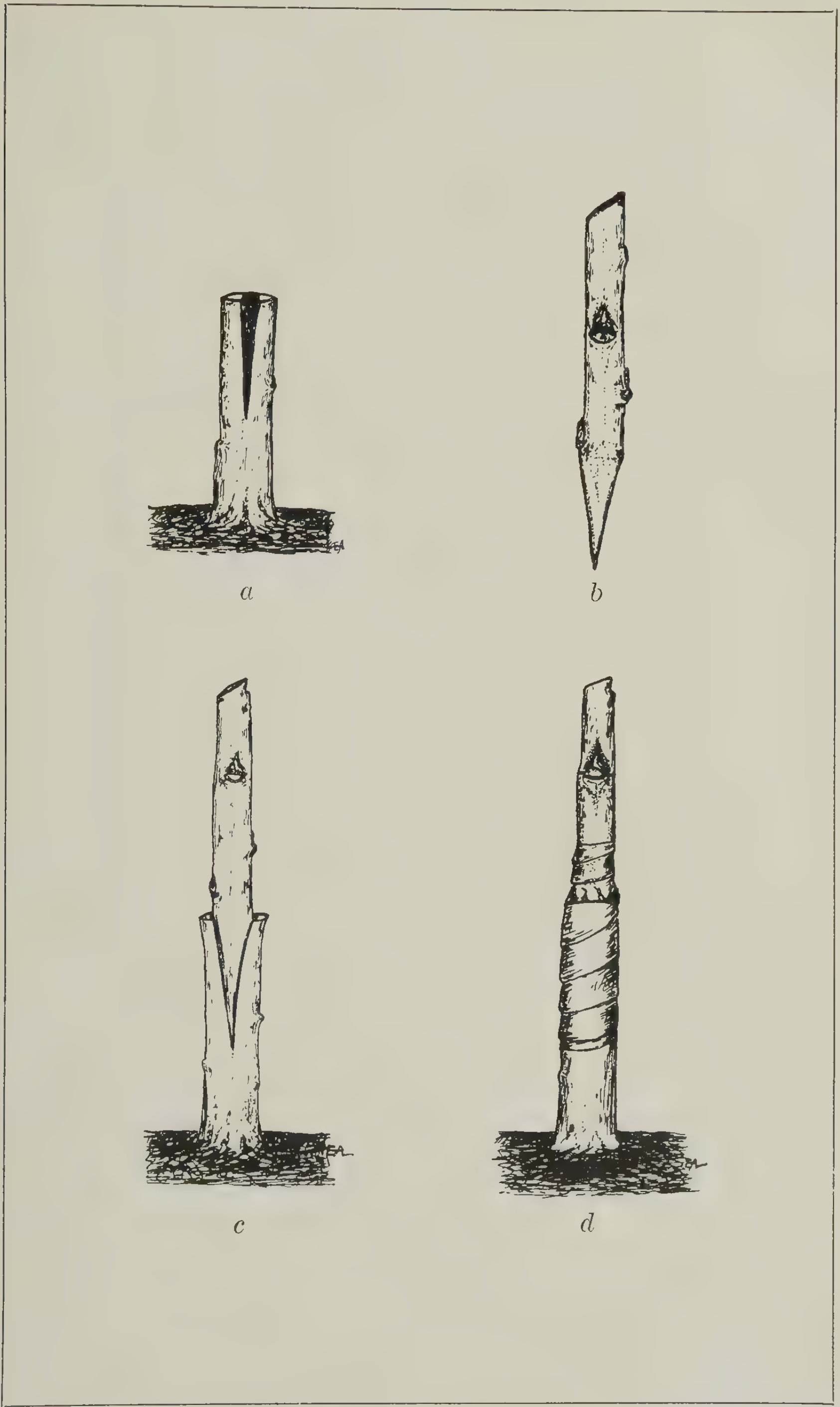
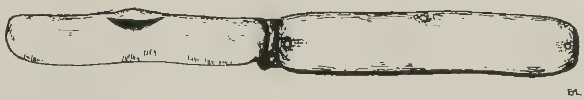


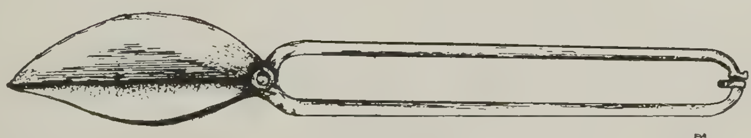
PLATE 3.

a

b



c



d

PLATE 4.

a

b

PLATE 5.

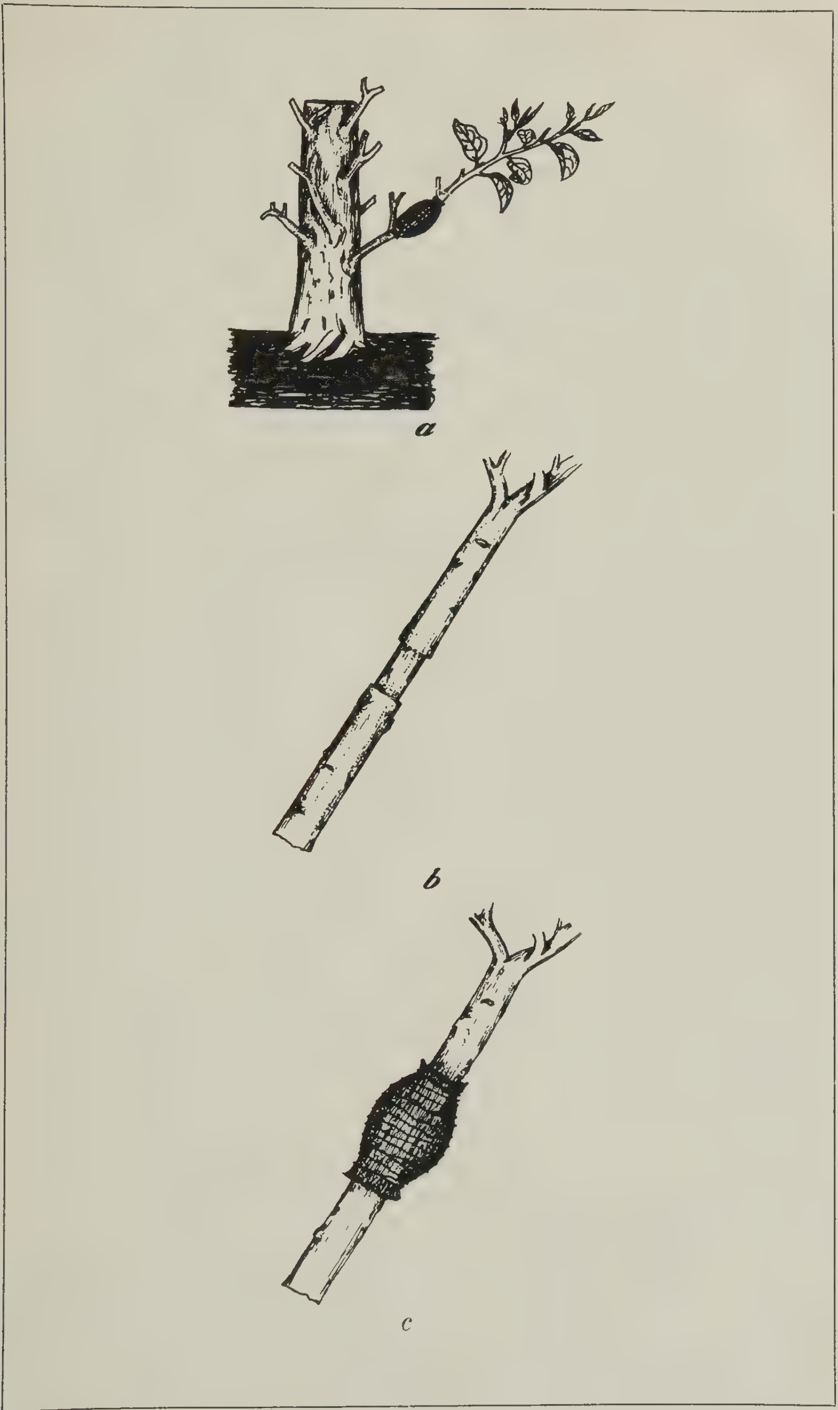
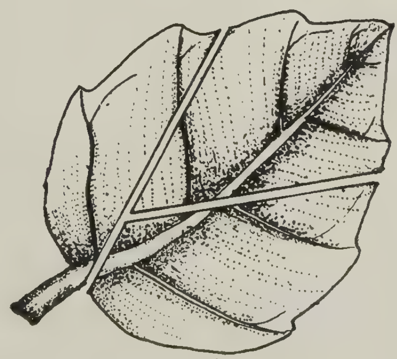


PLATE 6.

a

b

c



d

PLATE 7.

BOOK REVIEW

We have just received a copy of the Technical Communication No. 7 of the Imperial Bureau of Fruit Production, East Malling, Kent, England, entitled "Vegetative propagation of tropical and subtropical fruits" by G. St. Clair Feilden. The author begins his subject by describing and illustrating the different methods of vegetative propagation such as budding (flute or modified patch, forkert or modified forkert, patch, ring and shield budding), etiolation method, grafting (saddle, side, tongue, slotted side, splice, wedge and whip grafting), inarching, layering and marcotting together with the preparation of grafting wax and the petioled and non-petioled budwoods. The first part is of particular interest to the students in horticulture who want to be familiar with the different methods of vegetative propagation now in practice.

The second part of the paper deals mainly with the vegetative propagation of the various tropical and subtropical fruit trees including the stock plants. This portion is of exceptional value to the orchardists since it enumerates not only the best stocks and scions for each of the mentioned fruit trees especially the varieties with economic value in the Philippines like the mangosteen, lanzon var. duku, mango, avocado and chico. Besides the right time and methods of propagation suited for them basing upon the results obtained in Java, India, Ceylon, Philippines, Hawaii, United States and elsewhere. However, mention should be made that the compilations herein under review do not include the Philippine results reported after Wester's work had been published in 1920, Bul. 32—The Plant Propagation and Fruit Culture in the Tropics—as regards vegetative propagation experiments conducted by the Bureau of Agriculture, now Bureau of Plant Industry, as published in the Philippine Agricultural Review, Vols. 13 and 17 (1920 and 1924), the Philippine Farmer, Vol. 6 (1920), and the Philippine Journal of Agriculture, Vol. 2, No. 4 (1931).

Special emphasis should be mentioned as regards the possibility of budding or grafting the mango and avocado embryos, and the success made in Martinique in grafting the mango on cashew, *Anacardium occidentale* L., which according to the author, the resulting plants were reported to have produced fruits double in size, free from fiber and with very small seeds.

BUREAU OF PLANT INDUSTRY

AGRICULTURAL STATIONS

1. Central Experiment Station, Manila
2. Lamao Horticultural Station, Limay, Bataan
3. Lipa Coffee-Citrus Station, Lipa, Batangas
4. Tanauan Citrus Station, Tanauan, Batangas
5. Granja Sugar-Cane Station, La Granja, Occidental Negros
6. Gandara Seed Farm, Gandara, Samar
7. Baguio Plant Industry Experiment Station, Baguio, Mountain Province.
8. Maligaya Rice Station, Muñoz, Nueva Ecija
9. Ilagan Tobacco Station, Ilagan, Isabela
10. Maridagao Rubber Station, Pikit, Cotabato
11. Moriones Plant Propagation Station, Pili, Camarines Sur
12. La Paz Propagation Station, La Paz, Iloilo
13. Los Baños Economic Garden, Los Baños, Laguna
14. Sta. Maria Propagation Station, Sta. Maria, Ilocos Sur

SUB-STATIONS

1. Davao Seed Farm Project, Davao Penal Colony, Davao
2. Novaliches Mango Station, Caloocan, Rizal
3. Halcon Rubber Station, Baco, Mindoro
4. Gingoog Lanzon Station, Gingoog, Oriental Misamis
5. Mandaue Seed Farm, Mandaue, Cebu

TABLE OF CONTENTS

The articles in the Philippine Journal of Agriculture are indexed in the Agricultural Index, New York, N. Y.

Manuscript intended for publication in the Philippine Journal of Agriculture should be sent to the Chief, Publications Division, post-office box 302, Manila, Philippine Islands.

One hundred separates of each paper published in the Journal are furnished to the author without charge. Additional copies may be had at the author's expense if ordered when the manuscript is submitted for publication.

The journal is issued quarterly. The subscription price is 2 pesos (Philippine currency) or 1 dollar (United States currency) per year in the Philippine Islands and the United States and territories; 2 dollars (United States currency) in foreign countries. Single copies are sold at the same rates.

Subscriptions should be sent to the Chief, Publications Division, Department of Agriculture and Commerce, post-office box 302, Manila, P. I.

Publications sent in exchange for the Philippine Journal of Agriculture should be addressed: Scientfic Library Division, Bureau of Science, Department of Agriculture and Commerce, post-office box 774, Manila, P. I.